DOCUMENT RESUME

ED 216 870 SE 037 434

AUTHOR	Bredderman, Ted
TITLE	The Effects of Activity-Based Elementary Science Programs on Student Outcomes and Classroom Practices: A Meta Analysis of Controlled Studies.
INSTITUTION	New York State Univ. System, Albany.
SPONS AGENCY	National Science Foundation, Washington, D.C.
REPORT NO	NSF-SED-82-001
PUB DATE	Feb 82
GRANT	SED-79-18717
NOTE	86p.; Charts contain small print.
EDRS PRICE	MF01/PC04 Plus Postage.
DESCRIPTORS	*Academic Achievement; Conventional Instruction; Elementary Education; *Elementary School Science; *Process Education; Questioning Techniques; *Science Course Improvement Projects; Science Curriculum; Science Education; Science Instruction; Science Programs; Student Behavior; Teacher Behavior; *Teaching Methods
IDENTIFIERS	*Meta Analysis; National Science Foundation; *Science Education Research

ABSTRACT

A quantitative synthesis of research findings on the effects of three major activity-based elementary science programs developed with National Science Foundation support was conducted. Controlled evaluation studies of the Elementary Science Study (ESS), Science-A Process Approach (SAPA), or The Science Curriculum Improvement Study (SCIS) were used to examine effects on student outcomes and effects on classroom practices. For the effects on student outcomes, a meta-analysis of 57 studies resulted in 400 separate comparisons involving 13,000 students from 1,000 classrooms. An average improvement of 20 percentile units on science process tests for students in activity-based programs over those in other programs was found. This improvement was significantly greater for disadvantaged students and less for advantaged students. Effects on classroom practices were synthesized from 12 studies in which teaching practices were systematically observed during 1,800 science lessons presented in activity-based and non-activity-based classrooms. Results indicate that, on the average, the use of student hands-on activities increased by nearly 10% in the classrooms of the new programs. Talk decreased by 9% and lecturing by 7%. (DC)

NSF/SED-82001

The Effects of Activity-Based Elementary Science Programs on Student Outcomes and Classroom Practices
A Meta-Analysis of Controlled Studies

Ted Bredderman

State University of New York
at Albany

2/2/82

The Effects of Activity-Based Elementary Science Programs on Student Outcomes and Classroom Practices: A Meta-Analysis of Controlled Studies

The purpose of this report is to present a quantitative synthesis of the research findings on the effects of three major activity-based elementary science programs developed with federal support during the recent curriculum reform era. Two effects were examined in depth; the effects on student outcomes and the effects on classroom practices. For the effects on student outcomes, meta-analysis techniques described extensively by Glass, McGaw and Smith (1981) were used in integrating quantitatively the results reported for fifty-seven studies. Effects on classroom practices were synthesized from twelve studies carried out by investigators who employed systematic observation techniques in activity-based and non-activity-based classrooms. The mean percentage of time devoted to various types of events were compiled across studies.

Activity-Based Elementary Science Programs

The three activity-based programs selected for review, because of the relatively wide adaption by school districts, were ESS, the Elementary Science Study,

developed by the Educational Development Center (formerly Educational Services Incorporated); SAPA, Science-A Process Approach, the development of which was directed by the Commission on Science Education of the American Association for the Advancement of Science (AAAS); and SCIS, the Science Curriculum Improvement Study developed at Lawrence Hall of Science at the University of California, Berkeley, under the direction of Robert Karplus. These programs share a common set of departures from the "traditional", commercially available programs prevalent in the schools of the 1960's and early 70's. Smeroglio and Honigman (1973) summarized the distinctive traits of the new programs as follows.

1. They have resulted from collective efforts of scientists, teachers, administrators, and developmental psychologists.

2. They have been tested in the classroom, modified and re-tested.

3. Psychological principles of cognitive growth and development have been used as guidelines.

4. They are activity-oriented, reflecting direct psychomotor experiences.

5. There are no texts for students, only teacher manuals and guidelines.

6. They contain "kits" of materials for students.

7. They provide in-service training for teachers.

8. They are process-oriented.

Beyond these common features each of the three programs is distinct in the relative stress placed on science process and content objectives, the degree of program structure, and the advocated instructional approach.

The Elementary Science Study (ESS), of the three major activity-based programs, is the least structured. The lack of prespecified, sequenced objectives and of detailed instructional procedures was defended by one of the project directors, Walcott (1965), on the grounds that:

> ...there is too much diversity in children, in schools, and in teachers. The goals of science education can be attained in many ways; students can travel many different roads and reach many destinations. It would seem more important to let them go in a direction they choose than either to lead or push them down a predetermined path, however worthwhile it may be (p. 1).

The program is organized into fifty-six independent units with no fixed sequence across the elementary grades. Life and physical science units are included as well as several units involving activities in spatial relations, logic and perception. Activities are included both for their motivating quality and the opportunity they provide for problem solving and understanding of natural phenomena. Activities are often started with a challenge, problem or

perplexing event, followed by a period of open ended exploration and concluded with a class discussion. Evaluation is usually accomplished informally, through observing children during instructional activities or examining their work.

The Science-A Process Approach (SAPA) program is a highly structured program developed to teach specific science processes. The argument presented by Gagne (1963), a principle architect of the program, contrasts sharply with the defenders of ESS:

> ...if transferable intellectual processes are to be developed in the child for application to continued learning in sciences, these must be separately identified, learned, and otherwise nutured in a systematic manner... one must learn to carry out critical and disciplined thinking in connection with each of the processes of science. (p. 53).

The program is organized around eight basic and six advanced science processes. Each of the processes is broken down further into small steps for instructional purposes. All of these steps are expressed in behavioral terms and sequenced in a hierarchical arrangement. The content, on which the processes are practiced is drawn from both the life and physical sciences and is selected primarily because it presents a clear situation in which the process step being taught can be applied. Because of the sequenced nature of the objectives, evaluation at

each step is provided, to be used with individual students or with the whole class.

The Science Curriculum Improvement Study (SCIS), has as its primary goal the development of scientific literacy, defined by the program director, Karplus (1972), as a "combination of basic knowledge concerning the natural environment, investigative ability...and curiosity." The program consists of twelve units, one life and one physical science unit at each elementary grade level. The units stress what the authors believe to be major fundamental concepts such as object, system, interaction, energy source and receiver, organism, population, community, and ecosystem. Approximately ten major concepts are developed each year. The concepts are interrelated and are intended to provide a conceptual framework for the child's thinking. The program is based on the assumption as expressed by Karplus and Thier (1966) that "...children must be led to form a conceptual framework that permits them to perceive phenomena in a more meaningful way and to integrate their inferences into generalizations of greater value than they would form if left to their own devices (p. 1)." Opportunity is provided for developing science processes as well. The general instructional pattern is to allow for free exploration of new materials, to introduce or "invent" a new concept, and then to allow

the new concept to be applied in a range of new situations. Evaluation is accomplished through observation during activities and through examination of work in student manuals.

Meta Analysis of Effects of Activity-Based Programs on Learning Outcomes

Although there were extensive formative evaluation procedures carried out during the development phase of each of the projects, there have been no nationally coordinated evaluation efforts to assess the effects of the activity-based programs on children in school districts adopting the programs. Fortunuately during the past decade a number of independently conceived evaluation studies have accumulated. Since most of this work has been reported in the form of doctoral dissertations, and unpublished, it has received little attention from the audiences which might benefit from the information.

th (1969) and Gallagher (1972) presented early narrative reviews and more recently Welch (1979) reported on a qualitative summary of evaluation results of some of the studies on activity-based programs. The present analysis is intended to be an up to date, comprehensive, quantitative synthesis of all of the available research and evaluation work in this area.

Method

Locating Studies

The first step in the meta-analysis of outcomes was to locate every study available from standard library sources. Both a computer and hand search were made of Dissertation Abstracts International, the RIE and CIJE indexes of the Educational Resources Information Center (ERIC), and Education Index. Recent issues of the periodicals, Journal of Research in Science Teaching and Science Education and all issues of The Annual Review of Research In Science Education and the programs of the annual meetings of the National Association for Research in Science Teaching were searched. Bibliographies produced by the three activity-based science projects and bibliographies of each located report were used to locate additional studies. Approximately one-hundred reports of effects on student outcomes were located.

Two requirements for inclusion of a study in the quantitative synthesis reduced the number of studies to fifty seven. First, the study design had to include a control group and second, the report had to contain sufficient information to calculate effect size. In the hope of salvaging a few more studies, letters were sent to some authors requesting further information; no replies were received. The complete listing of studies, identified by author and grouped by particular activity-based

program and outcomes area investigated, is presented in Table 1.

Of the 57 studies, 70% were originally reported as dissertations. More than 1000 classrooms and over 20,000 students were involved in all studies. Fifty-eight percent of the investigators used more than ten classrooms. Many researchers capitalized on inservice or university based teacher training efforts in identifying teachers who were using the programs. Typically, the recently trained teachers were compared with teachers in the same school or neighboring schools where the program had not been adopted. Seventy-nine percent of the studies had static groups or non equivalent control group designs (Campbell and Stanley, 1963) which are considered quasi-experimental designs because they do not include random assignment of subjects to treatments. Forty-eight percent of the investigators tested effects after more than one year of program use.

Describing Study Features

The studies being integrated varied considerably in ways which could potentially affect the reported results. Meta-analysis techniques include procedures for testing empirically, whether or not study features have an effect. However, these tests require that study features be coded and treated quantitatively in the analysis. A preliminary

Table 1

Studies Included in the Analysis Grouped by Outcome Area and Activity-based Program

Outcome Area Studied	Program: ESS	Program: SAPA	Program: SCIS
Science Process	Barksdale 73 Mansfield 78 Schmederman 69	Beard 70 Bredderman 74 Bullock 72 Cleminson 70 Jacknick 75 Judge 75 McGlathery 67 Partin 67 Ransom 68 Somers & Lagdamen 75 Wideen 75	Allen 67, 70, 72, 73a, 73b Billings 76 Bowyer 78 Linn & Peterson 73 Linn & Thier 75 Linn 72 Maxwell 74 Riley 72 Weber 71 Wright 76
Science Content	Blomberg 74 Smith 72	Davis, Raymond, MacRawls & Jordan 76 Jacknick 75 Novinsky 74 Partin 67 Raven & Calvery 77 Smith 72 Veidovic 73 Wideen 75	Billings 76 Bowyer 78 Linn 72 Long 73 Riley 72 Smith 72
Affect	Barksdale 73 Johnson 74	Jacknick 75 Kolebas 71 Novinsky 74 Partin 67 Wideen 75	Allen 72, 73b Brown 73 Hofman 73 Krockover & Malcolm 77 Linn & Thier 75 Lowry 79 Malcolm 75 Riley 72 Wright 76
Creativity	Fick 76 Hunsberger 76	Davis, Raymond, MacRawls & Jordan 76 Novinsky 74 Ransom 68	Brown 73
Language Development	Mansfield 78	Ayers & Mason 69 Davis, Raymond, MacRawls & Jordan 76 Huff 73 Kolebas 71 Raven & Calvey 77 Yow 75	Coffia 71 Heath 70 Kellogg 71 Mansfield 78 Maxwell 74
Mathematics		Ayers & Mason 69 Davis, Raymond, MacRawls & Jordan 76 Kolebas 71 Raven & Calvey 77	Coffia 71 Kellogg 71 Maxwell 74
Perceptual Development		Ayers & Mason 69 McGlathery 67	Battaglini 71 Kellogg 71 Maxwell 74
Logical Development	Labinowich 70	Bredderman 74 Cleminson 70 Howe & Butts 70 Raven & Calvey 77	Bowyer 78 Hansen 73 Linn 72 Long 73
Intelligence		Johnson 70 Kolebas 71	Stafford 69

reading of the identified studies in the present analysis led to the defining of fifteen study features which were described with sufficient frequency to warrant their inclusion in the coding system. The variables, their values, and the number of studies coded for each value are presented in Table 2. Five variables define methodological features; three define treatment conditions; three, student characteristics; two, publication features and one variable defines learning outcomes of studies. The variable names and the definitions of their values are as follows:

Methodological Features

Random assignment of students to comparison groups. Was a random or matched pairs technique used to assign students to activity-based and non-activity-based groups as opposed to using intact classes?

Control of instructor effect. Did the same instructor teach both experimental and control groups?

Form of test administration. Was the outcome instrument administered in paper and pencil form to the whole class or was another form of test administration used such as using audio-visual or manipulative materials with small groups or in individual interviews?

Test source and standardization. Was a commercially available, nationally standardized test employed as opposed

Table 2

Number of Studies for Coded Variable Categories

Coded Variables and Categories	Number of Studies
Methodological Features:	
Random Assignment of Comparison Groups	
(1) No	46
(2) Yes	12
Control of Instructor Effect	
(1) Same instructor for both groups	8
(2) Different instructor/volunteers	11
(3) Different instructor/random or mandated	39
Form of Test Administration	
(1) Paper and pencil with whole class	26
(2) Audio-Visual with whole class	16
(3) AV or manipulatives with small group	7
(4) Manipulatives with individuals	18
Test Source/Standardization	
(1) Investigator develop	30
(2) Limited standardization	17
(3) Commercial-nationally standardized	22
Sample Size	
(1) Ten or fewer classes	
(2) More than ten classes	
Treatment Conditions:	
Activity-based science program	
(1) ESS (Elementary Science Study)	9
(2) SAPA (Science A Process Approach)	22
(3) SCIS (Science Curriculum Improvement Study)	28
Control Group Treatment	
(1) Teacher autonomous or undefined	29
(2) Science text	26
(3) Laboratory program or Lab-text program	8
Duration of Treatment	
(1) One year or less	38
(2) More than one year	20
Student Characteristics:	
Grade Level	
(1) Kindergarten through third grade, K-3	27
(2) Fourth through sixth grade, 4-6	35
Advantaged Status	
(1) Handicapped: physically, mentally retarded	
(2) Disadvantaged: inner city, rural, low ability	14
(3) Average: cross-section, average ability	34
(4) Advantaged: suburban, high ability, gifted	16
Gender	
(1) Male	11
(2) Female	11
Publication Features:	
Source of report	
(1) Unpublished report or dissertation	34
(2) Published dissertation or report	23
Year of publication report	
(1) 1967-69	6
(2) 1970-72	18
(3) 1973-75	22
(4) 1976-78	10
(5) 1979-81	1

to an experimenter developed test or test of limited previous use?

Test bias. Did the test match the objectives or teaching activities of one of the two treatments being compared more than the other? Test or test descriptions and program activities were examined in making this judgement. Each test was rated twice, several months apart, by this author. There was over 95 percent agreement between the two ratings.

Sample size. Were a total of ten or more classes used in the study?

Treatment Conditions

Activity-based science program. Which of the activity-based programs, ESS, SAPA or SCIS was being compared with a control group?

Control group treatment. What was the nature of the science program being experienced by the control or comparison group? Was the program a "teacher autonomous program" in that there was no indication in the report that a commercially available program was being used or in that it was indicated specifically that the program was locally developed? Was it specifically stated that a commercially available "text" program was used? Was it specifically stated that a "lab-text" combination or a laboratory program other than ESS, SAPA or SCIS was used?

Duration of treatment. How long were the students involved with the program before final outcome tests were administered; one year or less, or more than one year?

Student Characteristics

Grade level. Were the students, at the time when outcomes were measured, in kindergarten through third grade or fourth through sixth grade?

Advantaged status. Were students handicapped, disadvantaged in other ways, average, or advantaged? Handicapped included students with physical handicapping conditions and educationally mentally retarded (EMR). Disadvantaged students included those described as inner city, rural, low socio-economic status, or low ability or intelligence. Average students were those who did not meet the conditions for either advantaged or disadvantaged students. Advantaged students were those described as suburban, high socio-economic-status, high ability, or gifted.

Gender. Because only eleven investigators reported results separately for male and female students, this data was coded and analyzed separately.

Publication Features

Publication status. Was the report ever published?

Year of publication. When was the study published

or if not published, what was the date of the report?

Outcome Area

Science process. Any study in which the outcome for a majority of test items required the student to handle natural science content by doing any of the following: analyzing, predicting, manipulating variables, problem solving, inferring, explaining from data, identifying variables, describing change and interaction based on observations, measuring, contructing histograms, observing properties and reporting on them?

Science content. Any study in which the outcome measure was a subtest of a commercially available standardized achievement test in which students were required to identify or respond with facts, concepts or principles relating to the natural world.

Creativity. Any study in which a test was described specifically as a test of creativity.

Language. Any study in which a test was described as measuring reading readiness, word meaning, vocabulary, comprehension, listening, expression or language arts abilities.

Mathematics. Any study in which a test was described as measuring mathematical computation, concepts, application, or readiness.

Perception. Studies in which perception tests were used, including non-spatial, spatial, figural, language and non-language tests.

Logical development. Studies using tests of Piagetian logical operations such as classification or seriation of generic content, conservation, conceptual logic, or combinatorial logic.

Affect. Studies using instruments described as measuring anxiety, attitude, satisfaction, appreciation, enjoyment, interest, motivation, exploratory motivation, curiosity, critical perception of learning environments and of amount learned.

Coding Unit

Because researchers compared groups on more than one outcome or reported comparisons for particular student subgroups separately, every reported comparison between activity-based and non-activity-based group was coded as a single case. For the fifty-seven studies a total of 400 comparisons were coded. Coding comparisons separately permitted aggregating comparisons from studies with common features and, by using weighting procedures, giving all studies equal weight in any sub-analyses. Weighting studies equally avoids the problem of potential interdependencies among the several comparisons which may have been coded for a single study.

Defining Dependent Measures

Three alternative indicators of activity-based science program effects were determined, whenever possible, for each comparison. First, the reported significance level and direction of effects were coded on an eight point scale. Second, the strength of the effect, ω^2, was recorded either as reported or calculated from t or F values. Third, effect sizes were calculated as suggested by Glass (1978); from means and control group standard deviations and from t and F values. Whenever possible, reported, unadjusted means were used or recalculated from ANCOVA data. When percentages of students passing specified cutoff scores were reported for activity-based and control groups, differences of standard normal deviates (z's), obtained from a table or normal curve values were used in calculating effect sizes.

Results

The overall effects of the activity-based programs on all outcome areas combined was clearly positive, although not dramatically so. Thirty-two percent of all 400 comparisons favored the activity-based program group and were reported as statistically significant at, at least, the .05 level. Only six percent favored the non-activity based program group at the .05 level of significance. These

results support rejection of the hypothesis of no effects since, if there were no effects, equal percentages of significant results favoring experimental and control groups would be expected.

Calculations of the percent of variance in outcomes accounted for by program differences (ω^2) indicate that for all outcomes combined, on the average, five percent of variance was accounted for. If only process outcome results were considered, on the average, the percentage of variance accounted for was ten percent. Welch (1979), based on his experience with The Harvard Project Physics evaluation concluded that:

> curriculum does not seem to have much impact on student learning no matter what curriculum variations are used...We at Project Physics eventually concluded that 5% (of variance) was an acceptable return on our investment since we could seldom find greater curriculum impact on the students...Changing 40% of the content in a variable that only accounts for 5% of the variance in the first place is not likely to produce dramatic effects (p. 301).

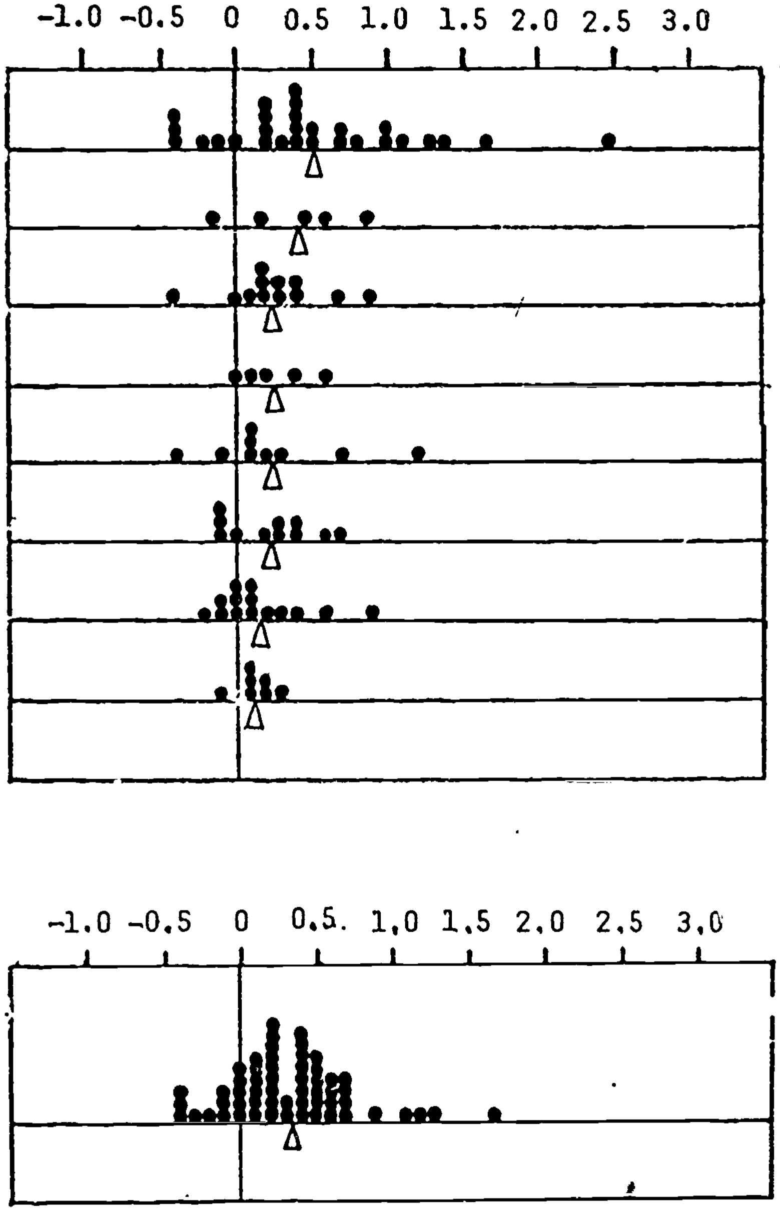
Many factors other than the program being used, such as student ability, time on task and teacher ability must have played a major role in how well students did on the tests used in these studies.

The mean effect size for all studies, weighted equally, on all outcomes was .35. This can be described as a small to moderate effect size (Cohen, 1977). It indicates about

a 14 percentile improvement for the average student as a result of being in the activity-based program group. Because of the variety of outcome areas tested and the influence of the relative number of studies for each on the mean effect size, it is important to examine the effects on each outcome area separately. The mean effect sizes of various outcome areas were somewhat different. The results are shown in Figure 1. The effects on measures of process and creativity can be considered moderate ($\overline{ES}$ = .52, $\overline{ES}$ = .42 respectively) and on all other outcome areas, small, although positive (from $\overline{ES}$ = .12 to $\overline{ES}$ = .27). We can be fairly certain that the use of activity-based programs relate positively to student achievement in these outcome areas with the one exception of effects on logical development. In all but this case the 95 percent confidence intervals around the population means do not include zero effect size.

One of the often heard reactions to the activity-based programs has been that they put too much stress on science process at the expense of content learning (Atkin, 1966; Ausubel, 1963; Labalm, 1966; Fishler, 1965). Victor and Learner (1971) expressed the view that:

> This enthusiasm about the process approach to learning science has become so great that the pendulum is swinging the other way, and process is beginning to be emphasized at the expense of content. Some of the new programs are paying



Outcome Area	Number of Studies	Mean Effect Size Δ	Standard Error	Median Effect Size
(a) Science Process	28	.52	.13	.39
Creativity	5	.42	.17	.47
Attitude	12	.27	.09	.27
Perception	5	.25	.11	.17
Logic	9	.25	.15	.14
Language	11	.23	.09	.26
Science Content	14	.16	.08	.07
Math	7	.12	.05	.11
(b) All Outcome Areas Combined	57	.35	.06	.34

Figure 1 Effect sizes for studies of activity-based elementary science programs grouped by outcome areas.

> little attention to learning concepts. The science content in the program is almost completely unstructured, and whatever content that is included is used only as a means of getting the child to learn process (p. 317).

At least when activity-based programs are compared with traditional science programs on standardized achievement tests of science content these fears appear to have been unwarranted. Content achievement was not seriously affected in a negative way even if the subgroup of studies, which contrasted activity-based programs with text programs, was considered ($\overline{ES}$ = .02 for 9 studies). Several investigators, have contrasted the teaching of science content using particular aspects of activity-based approaches, with more traditional methods, outside of the context of specific science programs. They have generally found that the activity-based methods produced greater science content learning (Davis, 1978; Marlins, 1973; Voelker, 1975; Vongchusiri, 1974).

The mean effect sizes for affective outcomes are generally small ($\overline{ES}$ = .28 for 15 studies) but consistent with those reported for other meta-analyses of innovative classroom practices. Peterson (1978) reported a mean effect size of .14 favoring open classrooms for seven affective outcome areas. Kulik, Kulik and Cohen (1980) reported a mean effect size of .24 on attitudinal measures favoring computer assisted instruction (CAI) over conventional

methods and a mean effect size of .18 for attitudes toward the subject matter in CAI over conventional classes. In the present analysis the mean effect sizes for various types of affective measures did not differ significantly. The size of effects which innovative methods can have on affective outcomes, in general, appears to be confined to a narrow range.

The small positive effects on language outcomes ($\overline{ES}$ = .23 for 11 studies) are attributable in large part to comparisons in a few studies of language expression at the early elementary grades ($\overline{ES}$ = .52 for 14 comparisons). Effects of comparisons for other language related outcomes are much smaller (Reading, $\overline{ES}$ = .10 for 40 comparisons; listening, $\overline{ES}$ = .20 for 5 comparisons).

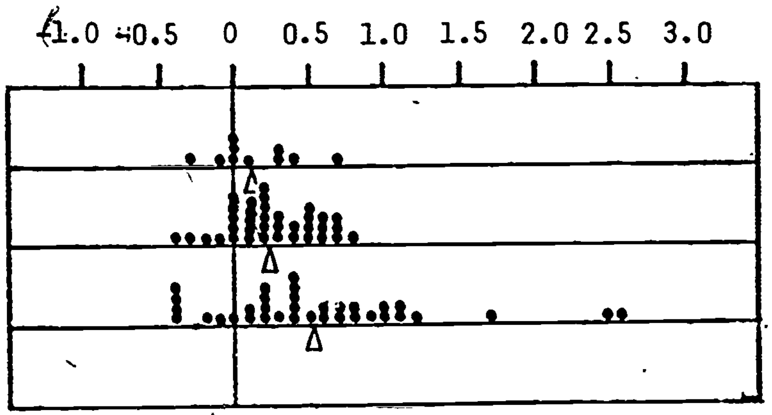
The expectation that the activity-based programs, with their problem solving orientation and provision for some free exploration, should lead to increased creativity is a reasonable one. Five investigators measured this outcome. Four of the five studies were done at the intermediate grade levels. The results generally confirm the expectation ($\overline{ES}$ = .42 for five studies) of positive effects. It is interesting that Peterson (1979) reported a positive, though smaller, effect size ($\overline{ES}$ = .18) for open over traditional classrooms based on eleven studies.

Study Features and Effect Sizes

In this section the results of zero order correlational analysis and multiple regression analyses of study features and effect sizes are reported. Then, the mean effect sizes for studies grouped by various study features are examined in detail with emphasis on those features most strongly related to effect sizes in the correlational analyses.

Correlation Analysis. Zero order correlations between each of the study feature variables and effect sizes were determined with each study given a weight of one. See Table 3. Two variables had significant correlations with effect size; student advantaged status (r=.25, d.f.=55, p=.03) and the rated bias of the outcome test (r=.22, d.f.=55, p=.05). These correlations indicate that higher effect sizes were obtained in studies of disadvantaged students and in studies in which outcome measures were judged to be biased toward the activity-based program. The mean effect size reported when disadvantaged student groups were compared was .65; those for groups classed as average or advantaged were .30 and .22 respectively. The mean effect size for studies in which outcome measures were judged to be biased toward the activity-based program was .54; that for unbiased measures was .24 and for measures biased toward the control group, .13 (see Figure 2a).

Multiple Regression Analysis. As would be expected from the generally low zero order correlations, linear combinations of study feature variables were not strong predictors of effect size. Each of the multiple regression analyses reported on here included the use of a weighting factor for multiple comparisons within studies so that each study contributed one degree of freedom to the analysis. When a step wise multiple regression analysis was carried



Outcome measure Test bias	Number of Studies	Mean Effect Size Δ	Standard Error	Median Effect Size
Favors comparison groups	10	.13	.09	.05
Unbiased	36	.24	.05	.19
Favors activity-based groups	35	.53	.12	.38

Figure 2a. Effect Sizes for studies of activity-based elementary science programs. Grouped by test bias categories.

out on the set of variables for which zero order correlations were reported, advantaged status and test bias variables accounted for 8.7% of the variance in effect size. With a new variable defined as process outcome (versus non-process outcome) was substituted for test bias in the variable set, the advantaged status and process outcome variables accounted for 9% of the variance in effect size. Neither of these or other multiple regression analyses which were carried out yielded statistically significant ($p < .05$) F values, indicating that it is not possible to reject the hypothesis that the population multiple R for combinations of study features and effect size is zero. Study features examined in this meta-analysis do not provide a strong basis on which to predict measured effects.

Table 3

Correlations of Study Features with Effect Size, Each Study Given Equal Weight, N=56

Feature	Correlation with Effect Size
Methodological	
Random Assignment (1=no, 2=yes)	.04
Control of Instructor Effect (1=same instructor, 2=different instructor)	-.03
Form of Test (1=paper and pencil, 2=other)	.13
Test Standardized (1=national standardization/ commercial, 2=other)	.08
Test Bias (1=not biased toward activity-based program, 2=biased)	.22*
Sample Size	.04
Treatment Duration (1=≤ one year, 2=< one year)	.01
Student Characteristics	
Grade Level (1=K-3, 2=4-6)	-.12
Advantaged Status (1=average and advantaged, 2=disadvantaged)	.25*
Gender (1=male, 2=female)	-.25 (N=22)
Publication Features	
Publication Status (1=unpublished, 2=published)	.16
Year of publication	.09

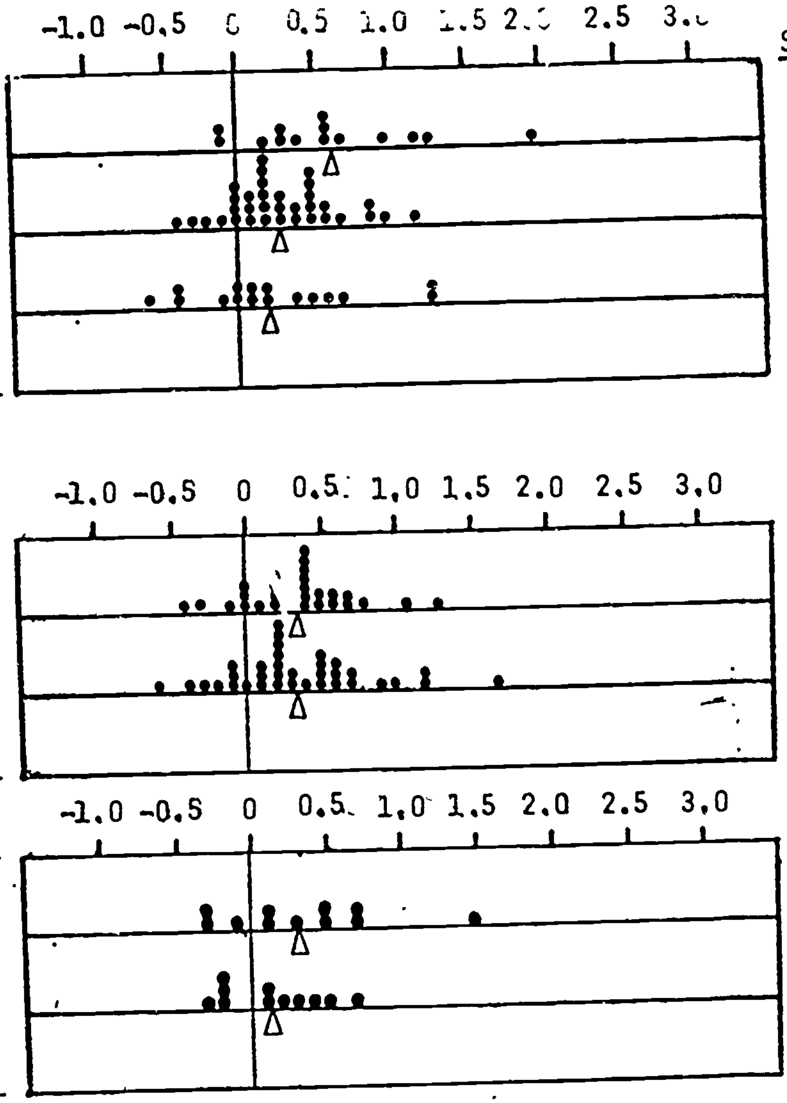
* $p < .05$

Student Characteristics and Effect Sizes

The three characteristics of students which were examined were advantaged status, grade level and gender. The effect sizes for each of the three variables is displayed by study in Figure 2.

The mean effect size for studies involving students in the primary grades was almost identical with those involving intermediate grade students ($\overline{ES}$ = .35 and $\overline{ES}$ = .34 respectively).

Studies of disadvantaged students had a mean effect size of .65 and those of average and advantaged students were .30 and .22 respectively. Neither of these latter two are within the 95 percent confidence interval of the mean effect size of studies of disadvantaged students. A greater mean effect size for disadvantaged students was found for all major outcome areas except the affective

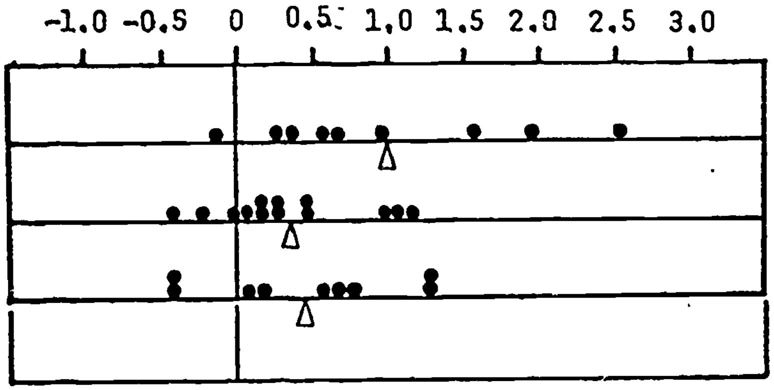


Student Characteristics	Number of Studies	Mean Effect Size (Δ)	Standard Error	Median Effect Size
(a) Student Advantaged Status				
Disadvantaged	14	.65	.15	.61
Average	34	.30	.06	.24
Advantaged	16	.22	.14	.17
(b) Student Grade Level				
K - 3	27	.35	.07	.35
4 - 6	35	.34	.08	.26
(c) Gender				
Male	11	.34	.16	.34
Female	11	.12	.10	.11

Figure 2 Effect sizes for studies of activity-based elementary science programs for all outcome areas combined grouped by sub student traits.

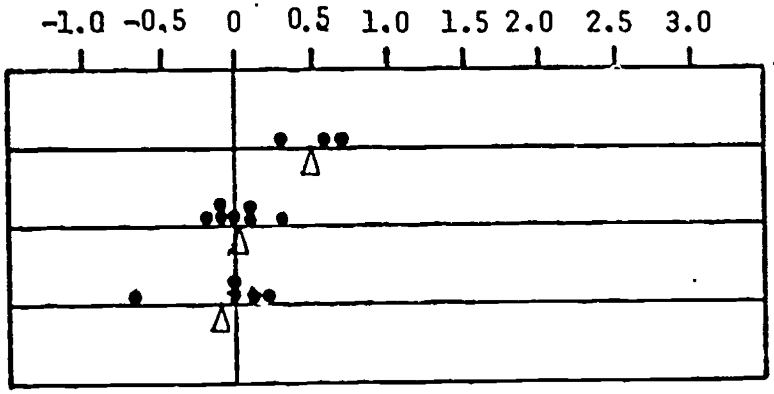
outcomes. In this case there was no difference between disadvantaged and other student categories. The effect sizes for science process and science content outcomes for each of the advantaged status categories are presented in Figure 3. Based on nine studies, disadvantaged students in activity-based classrooms outperformed those in non-activity-based classrooms by a full standard deviation on measures of science process. The mean effect size of studies of disadvantaged students on science content outcomes was .52 and those of average and advantaged students were .02 and -.10, respectively. The activity-based programs appear to help only disadvantaged students with regard to science content.

There is some evidence that the activity-based programs may have different effects on males and females. For most outcome areas there were no differences in mean effect sizes. However, in the three outcome areas, language development, mathematics, and perception where there were any noticeable differences, the effects were always greater for males. Since there were a total of only six studies in which these three outcomes were examined, the results should be viewed cautiously. If anything, males may benefit more from activity-based science. But, if so, the added benefit is in areas other than science process or content.



Advantaged Status	Number of Studies	Mean Effect Size	Standard Error	Median Effect Size
Disadvantaged	9	1.00	.29	.72
Average, Cross sectional	13	.36	.13	.28
Advantaged	9	.45	.21	.58

FIGURE Effect sizes for studies of activity-based elementary science program for science process outcomes, grouped by advantaged status of students



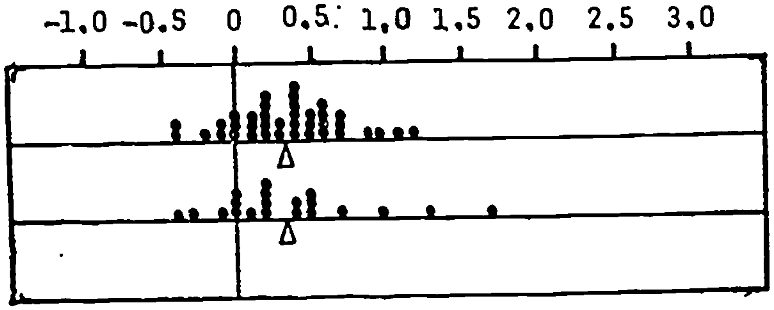
Advantaged Status	Effect of Studies	Mean Effect Size	Standard Error	Median Effect Size
Disadvantaged	3	.52	.13	.58
Average, Cross sectional	7	.02	.07	.00
Advantaged	5	-.10	.15	.03

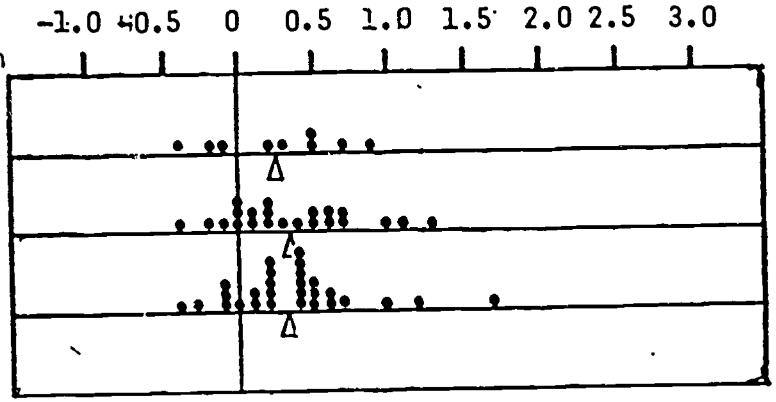
FIGURE 3 Effect sizes for studies of activity-based elementary science program for science content outcomes, grouped by advantaged status of students.

The three treatment features; (1) treatment duration; (2) specific activity-based program; and (3) the type of treatment received by the control group, failed to be significantly related to effect size in the correlational analysis. However, some tendencies emerged based on small numbers of studies when these study features were examined for effects on specific outcomes. Mean effect sizes for the features, for all outcomes combined are reported in Figure 4.

No influence of duration of treatment on effect sizes were evident for any outcome areas. The lack of increasing effect sizes with length of treatment suggests that the advantages derived initially from the activity-based experience are maintained but not compounded over time. Whether this advantage is maintained if the program is discontinued is open to speculation. Three investigators examined former students of the elementary activity-based science programs in the years after elementary school. Bredderman (1974) examined effects on logical development and science process outcomes in 8th and 10th grade. Wright (1976) measured effects on attitudes and process outcomes in 7th grade. Raven (1977) investigated science content and logical and language growth of 8th grade students. The mean effect size of the thirteen comparisons in the three studies was zero. Eight comparisons were negative and only one (Raven's

Treatment Feature	Number of Studies	Mean Effect Size Δ	Standard Error	Median Effect Size
a) Treatment Duration				
One year or less	38	.34	.06	.35
More than one year	20	.34	.11	.20
b) Activity-based Program				
ESS	9	.26	.14	.34
SAPA	22	.35	.09	.34
SCIS	28	.34	.08	.35
c) Treatment of Comparison Group				
Teacher autonomous programs	29	.43	.11	.35
Textbook program	26	.31	.08	.29
Lab-text program	8	.15	.11	.11





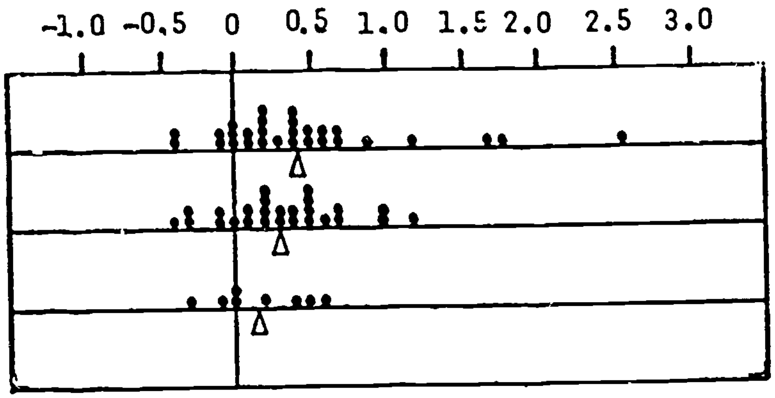


Figure 4 Effect sizes of studies of the effects of activity-based programs for all outcomes grouped by treatment features.

Table 4

Effects of Elementary School Activity-Based Programs Beyond Elementary School

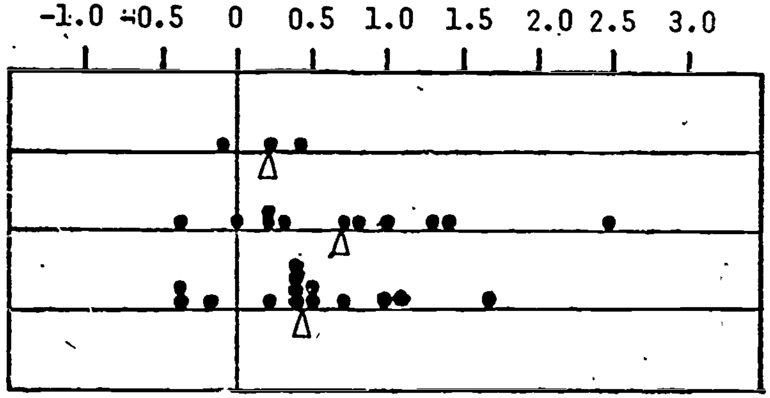
Author	Program	Grade Level(s)	Outcome Areas: Process	Content	Affect	Logic	Math	Language
Bredderman 1974	SAPA	8, 10	-.12, .14 (.01)*			-.50, .24 (-.13)		
Wright 1976	SCIS	7	-.19		-.41			
Raven&Calvey 1977	SAPA	8		-.01		.21, 1.19 (.70)	.06	-.06, -.05, -.11 (-.07)
Mean			-.09	-.01	-.41	.29	.06	-.07
Weighted grand means= -.005								

*Numbers in parentheses are mean effect sizes for the outcome of the study.

test of logic) was above .25. There is no evidence in these studies to indicate that the advantage gained and maintained during the years of activity-based science program use are sustained in the years following the program. The effect sizes of all comparisons testing retention beyond elementary school are shown in Table 4.

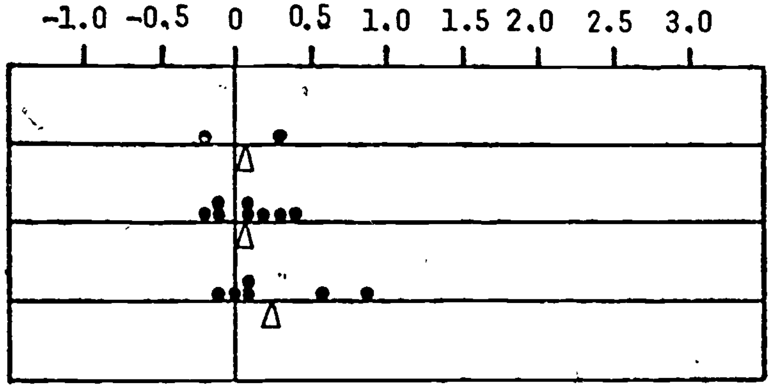
If effect-sizes on all outcomes are combined, there appears to be no major differences among the three activity-based programs, ESS, SAPA, and SCIS. But, when science process and content outcomes are examined separately, the relative emphases of the programs is evident. The effect sizes for these two outcome areas are reported for each of the programs in Figure 5. The highest mean effect sizes on process outcomes were reported for SAPA, ($\overline{ES}$ = .71) and SCIS ($\overline{ES}$ = .43). SCIS studies had slightly higher effect sizes on science content outcomes. However, this slight edge is derived from two studies in particular (Linn and Peterson, 1973; and Linn, 1972) which had the highest effect sizes. The two measures on which these effect sizes were obtained were both judged to be biased toward SCIS in science content on the test bias variable. SCIS also produced greater mean effect sizes on measures of logical development. Again, the tests used to assess the outcome in two studies with especially high effect sizes (Long,

a) Science Process Activity-Based Program



Science Process Activity-Based Program	Number of Studies	Mean Effect Size	Standard Error	Median Effect Size
Elementary Science Study (ESS)	3	.19	.14	.21
Science a Provess Approach (SAPA)	11	.71	.25	.72
Science Curr. Improvement Study (SCIS)	14	.43	.15	.39

b) Science Content Activity-Based Program



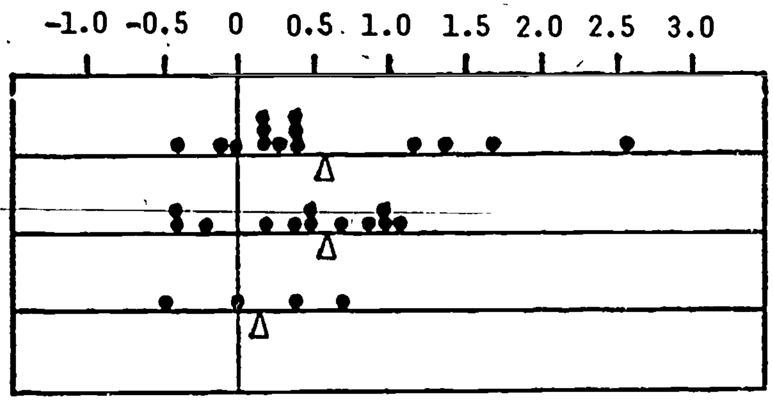
Science Content Activity-Based Program	Number of Studies	Mean Effect Size	Standard Error	Median Effect Size
Elementary Science Study (ESS)	2	.07	.27	.07
Science A Process Approach (SAPA)	8	.08	.06	.08
Science a Process Approach (SAPA)	6	.26	.16	.06
Science Curr. Improvement Study (SCIS)				

FIGURE 5 Effect sizes of various studies of the effects of activity-based programs on science process and content outcomes grouped by specific activity-based programs.

1973; Bower, 1975) were rated as biased toward the activity-based program.

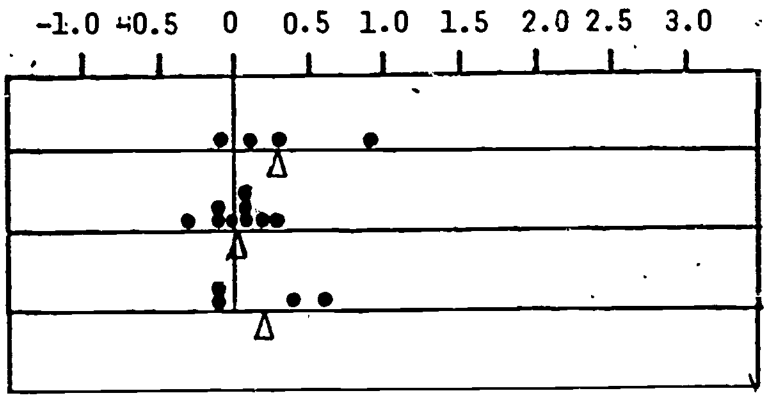
The importance of the match between what the activity-based programs stress as curricular outcomes and that which is measured in any evaluation of effects was clear from the earlier analysis. More positive effects were found for activity-based programs when the outcomes measured were those emphasized by these programs rather than by non-activity-based programs. The comparison of effects among the activity-based programs provides evidence of relative program emphasis. SAPA, a program designed to teach science process, more so than the other programs, results in the greatest effect on process outcomes. The use of SCIS, which puts more emphasis on content, leads to higher science content effect sizes, especially if the outcome measures emphasize the particular content stressed within the SCIS program.

There was a tendency for effect sizes to be smaller for studies in which any of the three activity-based programs was compared with a laboratory-text combination program or a laboratory-non-text program (see Figure 5a). This finding would be expected under the assumption that the positive effects of the activity-based programs were derived from the laboratory activity aspects of these programs. The effect sizes are especially lower for science process



Comparison Group Treatment	Number of Studies	Mean Effect Size	Standard Error	Median Effect Size
Teacher Autonomous or Undefined Program	14	.59	.22	.34
Science Text Program	13	.59	.22	.53
Lab or Lab-Text Program	4	.15	.26	.19

FIGURE 5a Effect sizes of studies of effects of activity based programs on science process outcomes grouped by comparison group treatments.



Comparison Group Treatment	Number of Studies	Mean Effect Size	Standard Error	Median Effect Size
Teacher Autonomous or Undefined Program	4	.30	.21	.19
Science Text Program	9	.02	.06	.07
Lab or Lab-Text Program	4	.19	.18	.14

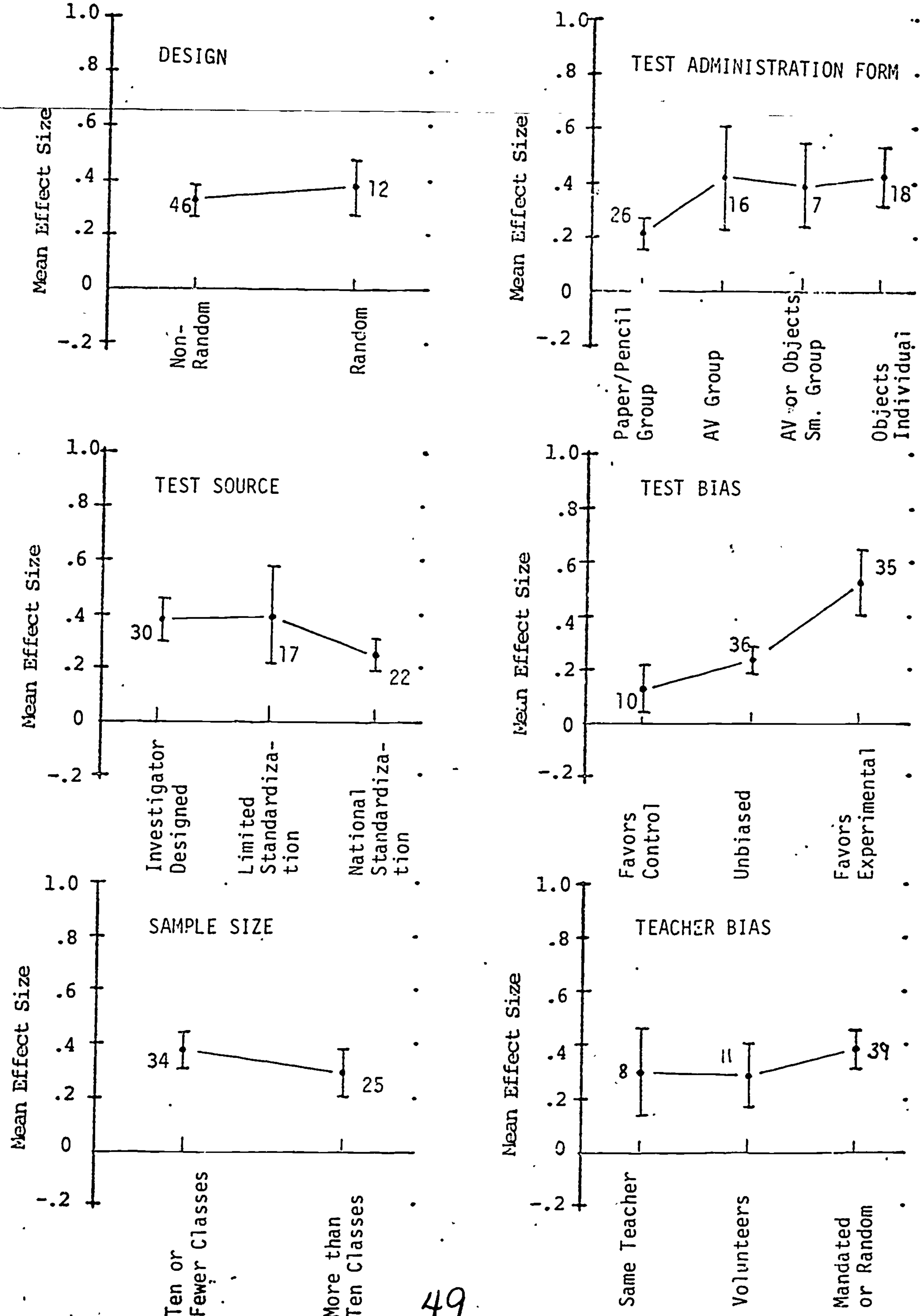
FIGURE 5b Effect sizes of studies of effects of activity-based programs on science content outcomes grouped by comparison group treatments.

and logical development outcome areas. There was a tendency for effect sizes to be near zero for science content outcomes when comparison groups were reported to be using textbook programs, Figure 5B. This result is consistent with the view that in text programs a more deliberate effort is made to teach science content than with the activity-based programs. If anything, such a view, leads to the expectation that effect sizes would be negative for studies in which content achievement comparisons are made. That they were not, raises the question of how students in activity-based programs, without texts, acquire the traditional science content to the same extent as students in the text programs. Karplus (1964) contended that lack of relevance and attention to the development of the child may be the sources of ineffectiveness of traditional programs.

> Instead of guiding this development in the direction of modern scientific understanding... the present day science courses create a second, separate, relatively abstract structure which is not used outside the school situation and which eventually atrophies.

The mean effect sizes for studies grouped by each of the methodological variables are shown in Figure 6. These data indicate that investigators who used nationally standardized tests, in paper and pencil, group administrations, and who used tests which were not biased toward

Figure 6 . Mean Effect Sizes Based on at Least Three Studies for Various METHODOLOGICAL FEATURES



the activity-based program tended to report lower effect sizes. These particular features are those which were found relatively infrequently in studies of science process outcomes. Table 5 shows the number of studies with these features and measures of process and content outcomes. The uneven distribution of studies between the two outcome areas indicates that the tendency for effect sizes to vary with these three study features may be a consequence of stronger effects of the activity-based programs on process as opposed to other outcome areas. If this is assumed to be true, it is likely that the methodological features may account, directly, for little if any of the variation in effects. The lack of sufficient studies with certain methodological features, and which included the measurement of science process, makes the confounding of the effects of method and outcomes unresolvable. However, the general finding of a lack of direct influence of methodological qualities on effect size would not be unusual (Glass, McGaw and Smith, 1981, p. 224-225).

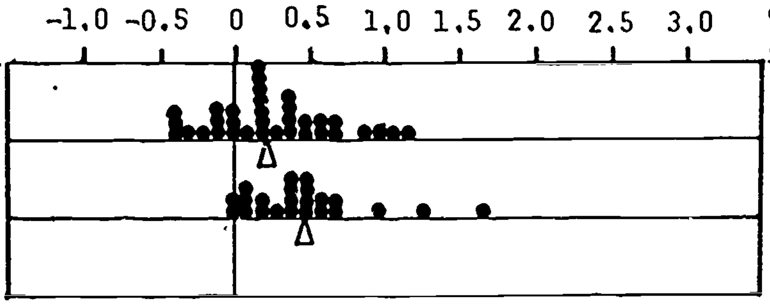
The effect sizes for the two publication features, year of publication and whether or not the report was published, are shown in Figure 7 . Studies were reported between 1967 and 1980. There was no pattern of variation in effect sizes associated with year of publication or

Table 5

Numbers of Studies with Selected Methodological Features and Measures of Science Process and Content Outcomes.

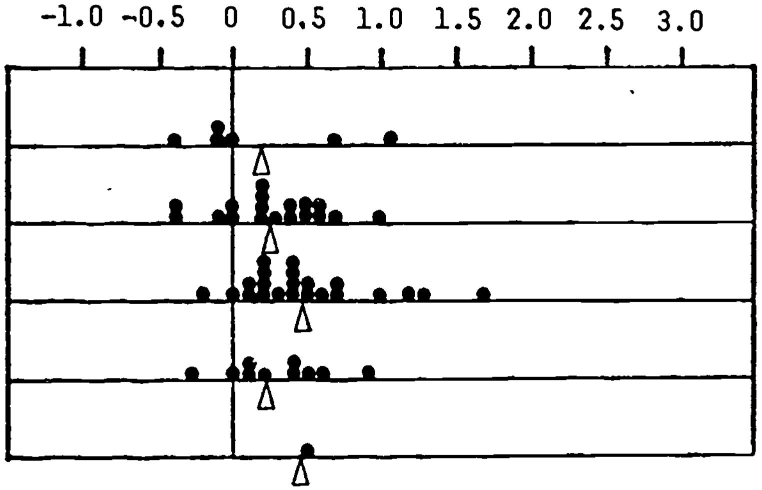
Methodological Feature	Outcomes: Process	Outcomes: Content
Instrument Used		
Not nationally standardized	28	7
Nationally standardized	0	7
Instrument Administration		
Paper and pencil/Group	5	10
Non paper and pencil	24	6
Test Bias		
Favoring Control	0	7
Favoring Activity-Based	27	5

a) Publication Status



Publication Feature / Publication Status	Number of Studies	Mean Effect Size	Standard Error	Median Effect Size
Published	34	.25	.07	.23
Unpublished	23	.48	.09	.41

b) Year of Publication or report



Year of Publication or report	Number of Studies	Mean Effect Size	Standard Error	Median Effect Size
1967-69	6	.20	.23	-.04
1970-72	18	.26	.09	.25
1973-75	22	.49	.10	.35
1976-78	10	.28	.11	.28
1979-81	1	.47	--	.47

Figure 7 Effect sizes of studies of the effects of activity-based programs for all outcomes grouped by publication features.

reporting. However, published reports had almost double the mean effect size ($\overline{ES}$ = .48) of unpublished reports ($\overline{ES}$ = .25). Glass, McGaw and Smith (1981, p. 226) report a 33% inflation of published over non-published effect sizes, based on a summary of nine meta-analyses.

The Effects of Activity-Based Probrams on Classroom Practices

Developers of the activity-based programs, in order to alter what was to be learned, set out to change the nature of elementary science classroom experiences of children. Simply stated, if children were to learn the investigative nature of science, they would have to become involved in investigations. The primary data source for the thought processes would have to be the objects of nature and the interactions of the child with those objects. The teachers role would shift from one who assigned text readings, conducted discussions on the readings and gave demonstrations, to one who organized students into investigative groups, managed laboratory materials, posed "thought " questions and helped students generally to ask researchable questions, and to gather and interpret data.

To answer the question of whether or not activity-based programs, when implemented, actually accomplished these changes in classroom practices, the literature was searched for all available studies which involved comparisons, based on systematic classroom observations, between traditional programs for teaching elementary

science and the three major activity-based programs, ESS, SAPA, and SCIS. Through searches of ERIC, CIJE, Education Index, Dissertation Abstracts International, current issues of the Journal of Research in Science Teaching and bibliographies of all reports identified from these sources, twelve studies were located. In general the studies fell into two categories, those which included a system for recording a spectrum of teacher and student verbal behavior, such as the Flanders Interaction Analysis Category System (FIAC), and those which looked at only the type of questions which were asked by teachers. In all but one case (Gates, 1976) the data was gathered during the first year of the teacher's use of the program. Features of each of the studies are presented in Table 6. A total of 467 teachers were involved in all of the studies. Approximately 1800 science class sessions were observed and coded by all investigators. Six investigators observed SCIS classrooms, five observed SAPA classrooms and one observed ESS classrooms. Eight included some primary grade classrooms in their sample and four included intermediate level classrooms. Two did not report the grade levels involved. In addition to contrasting activity-based with non-activity-based programs, several of the investigators contrasted the effects of inservice and summer training or the effects of consultant follow up help with the absence of these

Table 6

Features of Studies In Which Observed Teacher-Student Interaction of Activity-Based and Non-Activity-Based Science Lessons Were Contrasted

AUTHOR:	Bruce	Eaton	Fishler	Gates	Hall	Harty	Horine	Moon	Newport	Porter-field	West-meyer	Wilson
DATE:	1969	1974	1965	1976		1976	1971	1970	1970	1969	1967	1969
ACTIVITY BASED PROGRAM:	SCIS	SCIS	SCIS	ESS	SAPA	SAPA	SAPA	SCIS	SAPA	SCIS	SAPA	SCIS
POPULATION:												
Grade level(s)		4,5,6	4,5,6	1-6	2	K,1,2	2,3,4	primary	—	2,4	1,2,3	1,2,3,4, 5,6
Number of Classes Activity Based	33 post	23	10 post	30 trained	8 summer 8 inservice	8 consul- tant 10 no con- sultant	10	16	16 train- ing 16 no training	16	25 summer 25 inservice 30 untrained	15 15
Non-Activity Based	15 pre	19	10 pre	30 untrained	8	10	12	16	15	16	27 control	
Number of Districts	4	1	1	2	5	6	1	5	—			1
Teaching Training of Activity-Based Group	3 weeks summer	17 days workshop	4 work- shops & supervis- ed summer teaching		summer consul- tant inservice & super- vision	summer or summer & consultant		3 weeks	10 hours summer		5 weeks summer or 90 hours inservice or no training	
OBSERVATIONS:												
Type	Audio Tape	Video Tape	Audio Tape	Audio Tape	Audio Tape & Observer	Audio Tape	Audio Tape	Audio Tape	Audio Tape	Audio Tape	Audio Tape & Observer	Audio Tape
Number of sessions/teacher	1 or 2 pre 7 Total	3	2 pre 1 post	1	3	6	2	5 SCIS 2 Trad.	1	2	2	2
Time/Session (min.)			—	15	23	30	50	—	—		30	35
LAPSED TIME:												
First observation to last observation		4e	—	—	6	3	20e	40	2		16	1
Time of observation	Pre=Apr. June Sept-April	Feb. (Winter)	Fall	Jan.- March			end ea. semester Winter Spring	Pre Spring Fall Winter			Apr. May Spring	
Number of Categories	6	7	15	10	24	12	9	10	10	°	14	
Reliability check reported SO=Scott's coefficient		—	.84		SO=.64-.92	SO=.77	.8-.9	SO=.70-91	—			
Type	TQI	GAS	FIAC + STOI	FIAC	FIAC + IACT	FIAC aug- mented	FIAC con- densed	FIAC + STOI	FIAC	TQI- adapted	FIAC aug- mented	TQI

services.

Analysis

Based on a preliminary reading of all studies a composite category system of classroom practices was developed which would allow a test of whether or not the shifts in classrooms practices intended for activity-based programs had occured. The composite categories and their definitions are presented in Table 7. For each category the percentage of class time devoted to the category was tabulated. Since in general there was a shift away from the percentage of time reported for talk on the part of both teachers and students in activity-based classrooms, it was decided that percentages of total class time devoted to each practice obscurred shifts within subcategories. Thus it was possible, for example, for the absolute time spent on high level questioning to decrease although there was a shift from low level to high level questioning. To over come possibilities of this type, percentages of time devoted to smaller categories were determined relative to only the immediately larger category. Thus, for example, percentages of total questioning time devoted to low and high level questioning were calculated to see if a shift had occured from one type of questioning to the other. The intended

Table 7

Composite Classroom Behavior Categories as Defined by Various Investigators

Student Activity

overt activity (Hall 70), pupil experimentation (Horine 71), silence or confusion category of FIAC (Harty 76, Newport 70) student problem activity (Westmeyer 1967).

Student Initiated Talk

student answers with opinion or concept or student comments in response to nondirective question (Fishler 65), student comment or student question (Horine 71) student open, evaluative or divergent statement (Hall 70) pupil initiated talk to teacher (Harty 76) student initiated student talk (Newport 70) student question or student initiated idea (Westmeyer 67).

Student Responsive Talk

student answers with a statement of fact or comments in response to directive question (Fishler 65), student closed statement, memorative, cognitive, or convergent (Hall 70), pupil response to teacher talk (Harty 76, 71), student response (Horine 71, Westmeyer 67), teacher initiated student talk (Newport 70).

Lower Level Teacher Question

asks for, recognition, recall, demonstration of skill, comprehension (Bruce 69, Porterfield 69, Wilson 69) asks for, routine, cognitive memory, or convergent response, (Eaton 74), asks closed, memorative or convergent question (Hall 70), asks recall of facts, relationships, or to make observation (Fishler 65, Moon 71).

Higher Level Teacher Question

asks for analysis, synthesis (Bruce 69, Porterfield 69, Wilson 69), asks for divergent, evaluative response (Eaton 74), asks open divergent, evaluative question (Hall 70), asks to hypothesize or test hypothesis (Fishler 65, Moon 71).

Teacher Instructive Talk

teacher lectures or gives directions (Fishler 65, Horine 71),

Table 7 continued

gives new information or gives directions (Hall 70), teacher lecture or information giving or giving directions (Harty 76, Newport 70), teacher lecture, explanation or teacher direction (Westmeyer 67).

shifts in classroom practices as generally expressed in the literature for activity-based programs are depicted in Figure 8 for categories and subcategories.

Findings

The data and findings are shown in Table 8 and Figure 9. All studies showed a shift away from spending time on talk involving the whole class. The silence and verbal confusion category of FIAC was used in this analysis as the indicator of the shift away from talk when no specific student activity category was coded, as suggested by Newport and McNeill (1970). There was approximately a ten percent average shift away from talk and toward student activity for the ten available comparisons made between activity-based and non-activity-based groups involving a total of 273 classrooms. In traditional classrooms roughly 80 percent of the time was devoted to talk of student and teacher. In activity-based classrooms roughly 70 percent of the time was devoted to talk. This shift is in the intended direction, but probably less then the magnitude of shift one might expect from examining the teacher's guides and other training materials produced by the program centers.

The only other shift which was consistently reported was that of all teacher instructive talk, consisting of

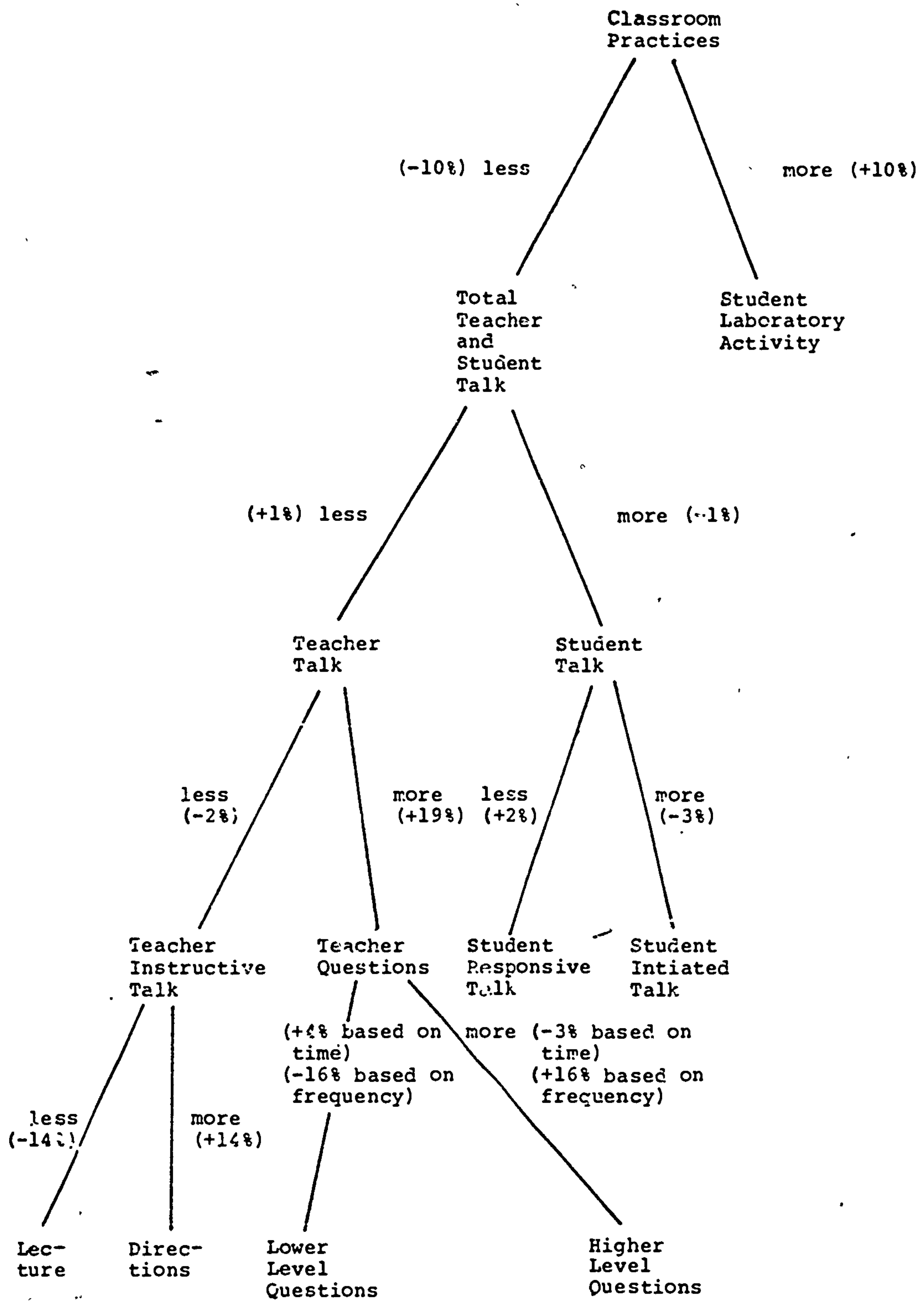


FIGURE 8 Expected shifts in classroom practices based on the instructional approached advocated for the activity-based elementary science programs and actual mean percent shifts (in parentheses) reported for controlled studies.

Table 8

Percentage of time devoted to various classroom practices by investigators of activity-based and non-activity-based elementary science classrooms.

Author	Bruce		Eaton		Fishler		Gates		Hall			Harty			Horine		Moon		Neuport			Westmeyer				Wilson		Totals		
Date	1967		1974		1965		1976		1970			1976			1971		1971		1970			1967				1969				
Program	SCIS		SCIS		SCIS		ESS		SAPA			SAPA			SAPA		SCIS		SAPA			SAPA				SCIS				
Observation	TQI		GAS		FIAC&STOI		FIAC		IAST			FIAC-Augmented			FIAC		FIAC+STOI		FIAC			FIAC-Augmented				TQI				
Treatment*	A/ST/C	N/U	A/ST	N/U	A/ST/S	N/U	A/T	N/U	A/ST/C	A/IT/S	N/U	A/ST/C	A/ST	N/U	A/	N/U	A/ST	N/U	A/ST	A/U	N/U	A/ST	A/IT	A/U	N/U	A/T	N/U	A/	N/U	
No. Classes	33	15	23	19	10	10	30	30	8	8	8	8	10	10	10	12	16	16	16	16	15	30	30	30	30	15	15	278	160	
Grade level	-		4,5,6		4,5,6		1-6			2			K,1,2		2,3,4		primary			-			1,2,3,			1-6		10	5	10
Composite Categories of Classroom Interaction Behavior and Percent of Time Reported for each Behavior																												Group M (SD)	Group M (SD)	Comparison
Student Activity									13.1	14.4	5.5	20.3	17.4	11.7	48.5	15.0			20.2	12.1	11.0	17.1	16.7	14.1	6.5			19.4 (10.5)	9.9 (3.9)	+9.5
Teacher & Student Talk									74.4	72.2	80.3	75.5	82.0	84.6	48.5	66.9			79.7	87.9	89.0	59.9	65.6	66.0	78.5			71.2 (11.5)	79.9 (8.3)	-8.7
Student Talk					34.4	30.1			18.4	18.2	23.9	25.4	28.4	29.3	16.8	21.5	49.0	39.0	28.4	23.1	24.6	18.9	21.7	19.5	28.8			21.9 (4.3)	25.6 (3.3)	-3.7
Teacher Talk					65.6	69.9	49.4	55.9	56.0	54.0	56.4	50.1	53.6	55.3	31.7	45.4	47.7	47.2	51.3	64.8	64.4	41.7	43.9	46.5	49.7			49.4 (9.0)	54.2 (7.2)	-4.8
Student Initiated Talk					25.9	19.2			0.1	0.4	1.6	10.6	7.4	12.4	4.2	7.1			13.1	5.1	.7.9	2.6	2.9	2.6	4.4			4.9 (4.3)	6.7 (4.0)	-1.8
Student Responsive Talk					8.4	10.9			16.7	16.2	20.6	14.8	21.0	17.0	12.7	14.4			15.4	17.9	16.7	16.3	18.8	16.9	24.4			16.7 (2.3)	18.6 (3.9)	-1.9
Teacher Questions					16.1	19.4			16.3	15.2	16.2	20.0	20.3	16.9	11.1	14.0			17.4	23.1	20.1	15.8	17.6	17.8	20.5			17.3 (3.3)	17.9 (2.7)	0
Teacher** Hi Level Questions	45.2 #	25.0 #	18.1 #	7.9 #	5.8	7.0			0.3	0.5	1.2						19.4 #	7.6 #								33.1 #	10.3 #	2.2 (3.1) 29.9 (12.8)	4.1 (-) 12.7 (8.3)	-1.9 16.3
Teacher** Low-Level Questions	54.8 #	75.0 #	81.9 #	92.1 #	10.3	12.4			16.0	14.8	15.0						80.6 #	92.4 #								66.9 #	89.6 #	13.7 (3.0) 71.0 (12.8)	13.7 (-) 87.3 (6.3)	0 16.3
Teacher Instructive Talk					40.8	41.0			25.4	24.8	23.0	19.6	24.7	30.4	12.7	21.0	19.0	17.7	22.5	29.0	31.5	21.0	20.7	23.7	23.7			22.4 (4.4)	25.9 (4.7)	-3.5
Teacher Directions					6.4	5.6			9.9	11.4	4.3	4.9	8.7	6.1	1.6	2.0			7.1	8.1	5.3	11.9	10.3	13.2	7.9			8.7 (3.5)	5.1 (2.9)	+3.6
Teacher Content Instructions					34.4	34.5			15.5	13.4	18.8	14.7	16.0	24.3	11.1	19.0			15.5	20.8	26.2	9.1	-10.4	10.5	15.8			13.7 (3.5)	20.8 (4.3)	-7.1

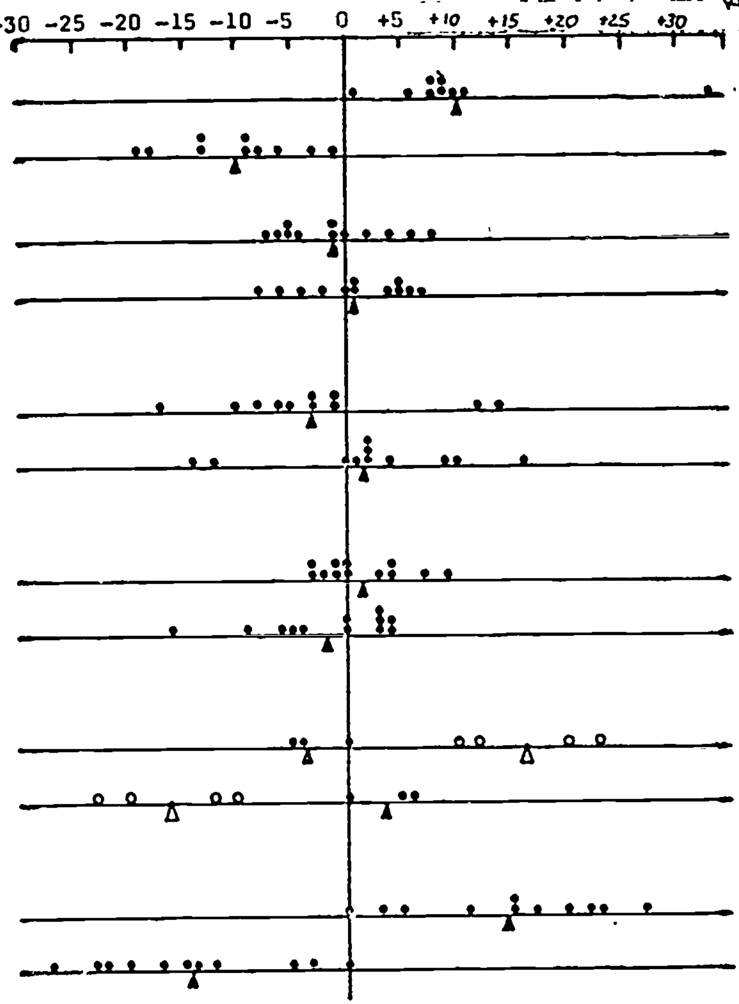
*Treatment: A = Activity-based Group, N = Non-activity based Group, ST = Summer Trained, IT = Inservice Trained, U = Untrained in Activity-Based Science
C = Consultant Services, S = Supervisory Services

**Questioning Level: # indicates that the number of questions asked rather than the time devoted to questions was reported by the investigator.
Totals include only reported percentages of time.

60

61

Percent Difference between Activity-Based (A) and Traditional (T) Groups (A-T) of:	Number of Comparisons	Mean Difference (%)	Standard Error	Median Difference (%)
Total Classroom Activity Devoted To:				
Student activity	10	+10.3	2.7	+8.8
Total talk of Teacher and Students	10	-10.0	1.7	-9.2
Total Talk Devoted To:				
Student talk	12	-0.8	1.4	-1.3
Teacher Talk	12	+0.8	1.4	+1.3
Total Student Talk Devoted To:				
Student Initiated or "Open" Talk	11	-2.6	2.7	-3.3
Student Responsive or "Closed" Talk	11	+1.7	2.6	+2.0
Total Teacher Talk Devoted To:				
Questions	12	+1.4	1.2	0.0
Instructive Teacher Talk	12	-2.0	1.8	-0.2
Total Teacher Questioning Devoted To:				
Higher Level Questions	3 4	-3.2 +16.2	1.6 3.1	-4.1 +16
Lower Level Questions	3 4	+3.5 -16.2	1.7 3.1	+4.8 -16
Total Instructive Teacher Talk Devoted To:				
Giving directions	11	+14.4	2.7	+16.5
Giving content information, lecture	11	-14.4	2.7	-16.5



● =% time
o =% frequency

Figure 9 Differences in practices observed in activity-based and non-activity-based elementary science classrooms.

both science related statements and procedural statements, roughly fiften percent more time was devoted to giving procedural directions, and conversely, fifteen percent less to content related lecturing. The increase in the giving of directions was noted by several investigators and attributed to the increased need for management behavior on the part of teachers in activity-based classrooms. Counter to expectations investigators using FIAC typically found that the ratio of indirect teacher techniques, such as accepting student feelings, praise and asking questions, to direct techniques, such as lecturing and giving directions, actually decreased in activity-based classrooms. This counter-intuitive finding, at least in part, can be explained by the increase in direction giving. In rough terms the findings suggest that an increase of ten percent in student activity results in an accompanying one third as much (3.6%) increase in direction giving.

The direction of shift in level of teacher questions depends on the method used to determine amount of questioning, that is, time devoted to or frequency of questions. If investigators used time as a measure -- for example the number of three second intervals devoted to high and low level questions -- a decreased percent (about 3%) of the time devoted to questions was spent on teacher high level questions in activity-based classrooms. However, if

observers counted the relative number of high and low level questions asked, there was about a sixteen percent increase in the number of questions which were classed as high level. These results suggest that high level questions may take less time to ask than low level questions. Divergent question's, such as "why"?, "what is your opinion"? and "Do you have an idea on this"? may require less teacher time than questions which must be sufficiently detailed to insure student convergence on the correct answer. The level of questions is important since other researchers have found that in elementary science classrooms higher level questions lead to higher level responses (Arnold, Atwood and Rogers, 1973).

In a related study by Porterfield (1969), transfer of questioning behavior, taught in SCIS training, to reading instruction was assessed. Second and fourth grade SCIS trained, reading teachers asked ten percent fewer recall questions and significantly more translation, intepretation, analysis, synthesis and attitude or value questions during reading instruction. It might be that the slight improvement in language development outcomes found in activity-based classrooms over non-activity-based classrooms, described earlier, is due in part to changed teaching behavior during reading lessons as well as the activity-based programs themselves.

The two expected shifts in classroom practices, which failed to materialize, related to student talk. Of the total observed talk there was no overall shift from teacher to student talk attributable to the use of activity-based programs, as one might have expected, and there was a slight decrease in total student talk which was of a student initiated type (-2.7%). This last result was based on 13 comparisons in six studies. For only two of the thirteen comparisons which included student initiated and responsive talk was the shift in the expected direction. A profile of classroom time devoted to various practices as reported in the twelve studies is presented in Figure 10. It should be kept in mind that in the studies summarized here, observers, in generals, did not code talk among students or between students and the teachers during activities. Individual student initiated talk during small group activities surely would affect the average percentages of such talk reported for activity-based (4.9%) and for non-activity-based classroom (6.7%).

In summary for the six shifts in classroom practices which were examined, four were at least in the expected direction, one marginally so, and two in the opposite direction, also marginally so. Figure 8 presents the expected and observed shifts for each category.

	Non-Activity Based % Time	Number of Groups	Activity-Based % Time	Number of Groups	Δ
Teacher and Student Talk	79.9 (8.3)*	5	71.2 (11.5)	10	-8.7
Teacher Talk	54.2 (7.2)	8	49.4 (9.0)	13	-4.8
Teacher Instructive Talk	25.9 (4.7)	7	22.4 (4.4)	12	-3.5
Student Talk	25.6 (3.3)	7	21.9 (4.3)	12	-3.7
Teacher Content Talk-Lecture	20.8 (4.3)	6	13.7 (3.5)	11	-7.1
Student Responsive Talk	18.6 (3.9)	6	16.7 (2.3)	11	-1.9
Teacher Questions	17.5 (2.7)	6	17.5 (3.3)	11	0
Teacher Low Level Questions	13.7 -	2	13.7 (3.0)	3	0
Student Activity	9.9 (3.9)	5	19.4 (10.6)	10	+9.1
Student Initiated Talk	6.7 (4.0)	6	4.9 (4.3)	11	-1.8
Teacher Directions	5.1 (2.9)	6	8.7 (3.5)	11	+3.6
Teacher High Level Questions	4.1 -	2	2.2 (3.1)	3	-1.9

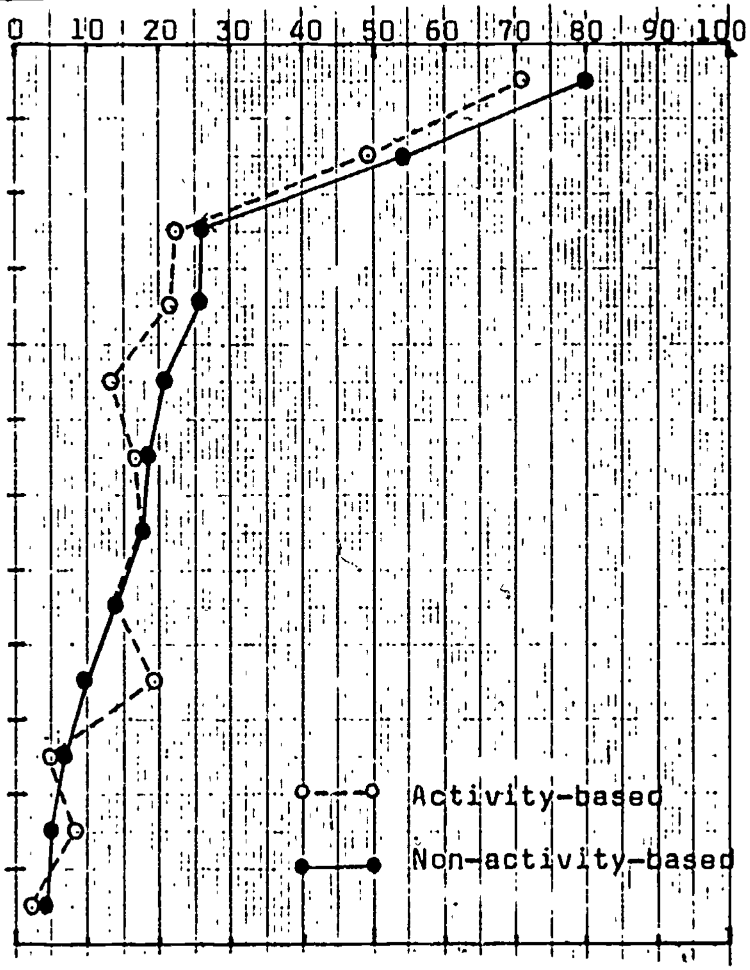


Figure 10 Percentage of time devoted to various classroom practices in activity-based and non-activity-based classrooms.

* Numbers in parentheses are standard deviations.

TABLE 2 Mean Effect Sizes Calculated by Three Different Techniques for Several Outcome Areas and For Different STUDENT CHARACTERISTICS T. Bredderman

OUTCOMES AREAS

		SCIENCE PROCESS			SCIENCE CONTENT			CREATIVITY			LANGUAGE			ALL AFFECT			ATTITUDE			MATH			PERCEPTION			LOGIC			OUTCOMES COMBINED		
		Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies
STUDENT CHARACTERISTICS																															
GRADE LEVEL																															
Primary	$\bar{ES}$	.66	.72	.51	+.01	+.00	+.01	+.13	---	+.13	.30	.32	.24	.29	.28	.36	.24	.24	.24	.17	.19	.15	.23	.24	.17	+.39	---	+.39	.42	.45	.35
	$S\bar{ES}$	.09	.41	.12	.07	.05	.05	.04	---	---	.07	.17	.11	.12	.13	.15	.06	.04	.06	.06	.05	.07	.08	.13	.08	.11	---	---	.05	.31	.07
	N	83	15	15	6	2	2	8	---	1	29	8	8	10	7	7	7	5	5	7	5	5	19	4	4	5	---	1	177	27	27
Intermediate	$\bar{ES}$	.52	.52	.52	.10	.04	.20	.55	.55	.55	.11	.15	.16	.21	.20	.28	.36	.35	.36	.08	.06	.14	.60	---	.60	.18	.15	.29	.27	.26	.34
	$S\bar{ES}$	.15	.18	.21	.06	.23	.09	.09	.14	.14	.08	.20	.17	.09	.12	.09	.10	.19	.11	.09	.05	.07	---	---	---	.12	.11	.15	.04	.17	.08
	N	37	15	15	56	12	12	28	4	4	25	5	5	24	9	9	16	8	8	10	3	3	1	---	1	20	8	8	204	35	35
ADVANTAGED STATUS																															
Disadvantaged	$\bar{ES}$	.95	1.01	1.00	.52	.52	.52	---	---	---	.50	.60	.31	.23	.20	.33	.26	.24	.29	+.10	---	+.10	.30	.34	.27	---	---	---	.65	.57	.65
	$S\bar{ES}$	.16	.45	.29	.16	.13	.13	---	---	---	.11	.20	.20	.12	.12	.19	.09	.05	.05	---	---	---	.12	.13	.13	---	---	---	.09	.33	.15
	N	33	9	9	3	3	3	---	---	---	12	3	3	7	3	3	4	2	2	1	---	1	11	2	2	---	---	---	69	14	14
Average or Cross-section	$\bar{ES}$	.51	.54	.36	+.05	+.04	.02	.40	.40	.42	.12	.15	.24	19	.17	.26	.27	.26	.25	.19	.19	.19	.18	.17	.22	.28	.27	.33	.26	.26	.30
	$S\bar{ES}$	.10	.22	.13	.04	.17	.07	.09	.18	.17	.03	.14	.21	.09	.13	.13	.09	.21	.13	.05	.04	.05	.11	.07	.13	.19	.07	.13	.04	.17	.06
	N	55	12	13	43	7	7	36	5	5	26	6	6	25	10	10	17	8	8	5	4	4	9	[illegible]	4	10	4	4	218	34	34
Advantaged	$\bar{ES}$	.45	.46	.45	+.01	.02	+.10	---	---	---	.07	+.07	.22	.45	.56	.34	.45	.56	.34	.11	.11	.10	---	---	---	+.08	+.05	+.11	.16	.14	.22
	$S\bar{ES}$	.16	.22	.21	.21	.16	.15	---	---	---	.08	.18	.15	.44	.33	.33	.36	.33	.33	.08	.01	.01	---	---	---	.10	.17	.14	.06	.16	.14
	N	25	9	9	9	5	5	---	---	---	17	3	3	3	2	2	3	2	2	12	2	2	---	---	---	17	3	3	84	16	16
GENDER																															
Male	$\bar{ES}$	.69	.64	.79	+.15	+.18	+.12	---	---	---	.38	.17	.67	.28	.22	.23	.26	.20	.10	.49	.49	.49	.32	---	.31	---	---	---	.24	.23	.34
	$S\bar{ES}$	.44	.38	.57	.15	.09	.08	---	---	---	.35	.56	.45	.14	.13	.23	.12	.13	.17	.12	.12	.12	.15	---	.00	---	---	---	.10	.14	.15
	N	6	4	4	12	3	3	---	---	---	5	3	3	13	6	6	11	5	5	2	2	2	2	---	1	---	---	---	43	11	11
Female	$\bar{ES}$	.66	.58	.80	+.04	+.07	.01	---	---	---	+.07	+.08	+.11	.29	.24	.31	.23	.19	.15	+.01	.00	+.01	+.44	---	+.43	---	---	---	.14	.14	.12
	$S\bar{ES}$	.45	.43	.61	.03	.13	.10	---	---	---	.09	.09	.11	.13	.13	.23	.10	.12	.13	.01	.00	.01	.11	---	.00	---	---	---	.05	.11	.10
	N	6	4	4	12	3	3	---	---	---	5	3	3	13	6	6	11	5	5	2	2	2	2	---	1	---	---	---	43	11	11

TABLE 3 Mean Effect Sizes Calculated by Three Different Techniques for Several Outcome Areas and For Different METHODOLOGICAL FEATURES — T. Bredderman

OUTCOMES AREAS

		SCIENCE PROCESS			SCIENCE CONTENT			CREATIVITY			LANGUAGE			ALL AFFECT			ATTITUDE			MATH			PERCEPTION			LOGIC			OUTCOMES COMBINED		
		Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies
METHODOLOGICAL FEATURES																															
DESIGN																															
Non-random	$\overline{ES}$	.62	.65	.52	.09	.04	.19	.04	.02	.05	.10	.10	.14	.19	.18	.24	.25	.25	.22	.13	.12	.16	.17	.16	.22	.20	.17	.36	.31	.32	.33
	$S\overline{ES}$	.08	.28	.14	.06	.22	.09	.07	.17	.17	.06	.13	.10	.03	.09	.11	.08	.15	.10	.06	.03	.04	.11	.06	.13	.11	.13	.16	.04	.24	.06
	N	111	25	25	58	12	12	15	2	2	43	8	8	32	13	13	21	10	10	17	6	6	13	4	4	23	7	7	323	46	46
Random	$\overline{ES}$	.45	.44	.48	.00	.03	-.02	.66	.66	.66	.50	.54	.45	.57	.62	.52	.57	.62	.52	-.10	---	-.10	.40	---	.40	-.30	-.47	-.12	.43	.43	.38
	$S\overline{ES}$	.14	.05	.08	.04	.05	.04	.11	.12	.12	.08	.17	.09	.29	.14	.14	.29	.14	.14	---	---	---	.09	---	---	.13	.26	.26	.06	.13	.10
	N	16	3	3	5	3	3	21	3	3	16	3	3	3	2	2	3	2	2	1	---	1	7	---	1	6	2	2	77	12	12
TEST AUTHOR																															
Investigator Only	$\overline{ES}$	.46	.45	.48	.12	.06	.20	---	---	---	.41	.37	.45	.19	.17	.24	.15	.15	.15	---	---	---	.60	---	.60	.10	.08	.28	.33	.33	.38
	$S\overline{ES}$	.07	.08	.11	.08	.27	.15	---	---	---	.09	.18	.18	.13	.15	.13	.14	.14	.14	---	---	---	---	---	---	.11	.17	.15	.04	.12	.08
	N	83	20	20	30	7	7	---	---	---	20	2	2	6	5	5	2	2	2	---	---	---	1	---	1	27	9	9	168	30	30
Limited Use	$\overline{ES}$	.87	1.21	.61	---	---	---	.64	---	.64	---	---	---	.29	.29	.24	.33	.34	.27	---	---	---	.17	---	.17	.05	---	.05	.63	.75	.40
	$S\overline{ES}$	.17	.74	.36	---	---	---	.17	---	---	---	---	---	.11	.11	.13	.11	.10	.13	---	---	---	.16	---	---	.16	---	---	.10	.37	.18
	N	44	8	8	---	---	---	7	---	1	---	---	---	13	7	7	12	7	7	---	---	---	8	---	1	2	---	1	80	17	17
Commercial Standardized	$\overline{ES}$	---	---	---	.05	-.05	.12	.34	.34	.36	.11	.08	.18	.18	.10	.39	.27	.14	.36	.12	.11	.12	.27	.35	.16	---	---	---	.17	.16	.25
	$S\overline{ES}$	---	---	---	.08	.19	.06	.10	.22	.21	.06	.14	.10	.13	.27	.28	.13	.67	.24	.06	.03	.05	.09	.18	.12	---	---	---	.03	.16	.06
	N	---	---	---	33	7	7	29	4	4	39	9	9	16	4	4	10	3	3	18	7	7	11	3	3	---	---	---	152	22	22
TEST ADMINISTRATION																															
Paper Pencil	$\overline{ES}$	.22	[illegible]	.13	.06	.00	.13	.40	.40	.42	.13	.12	.22	.16	.14	.25	.21	.20	.20	.13	.11	.17	---	---	---	.12	.21	.03	.19	.18	.22
	$S\overline{ES}$	.43	.19	.19	.06	.16	.07	.09	.18	.17	.06	.16	.12	.10	.12	.15	.10	.25	.15	.06	.04	.05	---	---	---	.22	.27	.27	.04	[illegible]	.06
	N	9	5	5	43	10	10	36	5	5	37	6	6	23	9	9	14	7	7	15	4	4	---	---	---	6	2	2	175	26	26
Audio Visual	$\overline{ES}$	.47	.43	.63	.02	.02	.02	---	---	---	-.04	-.05	-.03	.28	.28	.29	.38	.36	.37	.06	.06	.06	.22	.21	.27	.70	---	.70	.25	.23	.42
	$S\overline{ES}$	.18	.29	.32	.06	.06	.04	---	---	---	.04	.06	.06	.17	.16	.20	.16	.17	.15	.09	.09	.09	.11	.11	.13	---	---	---	.08	.18	.19
	N	21	9	9	9	3	3	---	---	---	9	4	4	7	3	3	6	3	3	3	3	3	7	4	4	1	---	1	57	16	16
AV or Group Manipulatives	$\overline{ES}$	1.13	1.49	.76	-.27	---	-.27	---	---	---	.63	---	.63	.43	.47	.38	.43	.47	.38	---	---	---	.26	.23	.29	---	---	---	.69	.89	.39
	$S\overline{ES}$	.19	.61	.61	.06	---	---	---	---	---	.10	---	---	.13	.09	.09	.13	.09	.09	---	---	---	.11	.12	.12	---	---	---	.12	.46	.16
	N	30	2	2	6	---	1	---	---	---	8	---	1	4	2	2	4	2	2	---	---	---	13	2	2	---	---	---	61	7	7
Individual	$\overline{ES}$	.46	.44	.53	.83	.85	.82	---	---	---	.55	.46	.63	.31	---	.31	---	---		---	---	---	---	---	---	.06	.06	.17	.41	.40	.43
	$S\overline{ES}$	.07	.09	.12	.08	.07	.07	---	---	---	.12	.14	.14	---	---	---	---	---		---	---	---	---	---	---	.12	.14	.19	.06	.12	.11
	N	67	13	13	5	2	2	---	---	---	5	2	2	1	---	1	---	---		---	---	---	---	---	---	22	7	7	107	18	18
TEST TREATMENT MATCH																															
Favor	$\overline{ES}$	---	---	---	.03	-.05	.05	---	---	---	.19	.30	.08	---	---	---	---	---	---	.19	---	.19	.33	.33	.33	---	---	---	.09	.06	.13
	$S\overline{ES}$	---	---	---	.06	.13	.08	---	---	---	.10	.18	.18	---	---	---	---	---	---	---	---	---	.42	.41	.41	---	---	---	.05	.17	.09
	N	---	---	---	30	7	7	---	---	---	15	2	2	---	---	---	---	---	---	1	---	1	2	2	2	---	---	---	48	10	10
Unbiased	$\overline{ES}$	.01	.04	-.03	-.02	-.17	.11	.34	.33	.41	.21	.19	.25	.22	.21	.28	.29	.28	.27	.13	.11	.17	.23	.26	.18	.13	.12	.13	.20	.19	.24
	$S\overline{ES}$	.58	.12	.17	.11	.32	.14	.09	.17	.17	.06	.19	.11	.08	.10	.11	.08	.13	.09	.06	.04	.05	.10	.12	.08	.13	.04	.02	.04	.10	.05
	N	6	4	4	21	6	6	32	5	5	42	9	9	34	14	14	24	12	12	15	4	4	7	3	3	14	4	4	182	36	36
Favor Experimental	$\overline{ES}$	.63	.65	.60	.41	.42	.36	.91	---	.91	.36	.36	.36	.31	---	.31	---	---	---	-.01	.00	.00	.25	.15	.38	.06	.02	.35	.54	.57	.53
	$S\overline{ES}$	.07	.27	.15	.11	.19	.16	.28	---	---	.42	.41	.41	---	---	---	---	---	---	.09	.09	.09	.12	.16	.12	.15	.23	.27	.06	.23	.12
	N	121	27	27	12	5	5	4	---	1	2	2	2	1	---	1	---	---	---	2	2	2	11	3	3	15	5	5	170	35	35

TABLE 3 Mean Effect Sizes Calculated by Three Different Techniques for Several Outcome Areas and For Different INSTRUCTIONAL CONDITIONS — I. Bredderman

		OUTCOMES AREAS																													
		SCIENCE PROCESS			SCIENCE CONTENT			CREATIVITY			LANGUAGE			ALL AFFECT			ATTITUDE			MATH			PERCEPTION			LOGIC			OUTCOMES COMBINED		
		Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies
ALL STUDIES	ES	.60	.63	.52	.08	.04	.16	.40	.40	.42	.21	.20	.23	.22	.21	.28	.29	.28	.27	.12	.11	.12	.25	.25	.25	.10	.08	.25	.33	.34	.35
	SES	.08	.27	.13	.05	.20	.08	.09	.18	.17	.05	.13	.09	.07	.09	.10	.08	.13	.09	.06	.03	.05	.08	.12	.11	.10	.15	.15	.03	.19	.06
	N	127	28	28	63	14	14	36	5	5	59	11	11	35	15	15	24	12	12	18	7	7	20	5	5	29	9	9	400	57	57
TREATMENT EXPERIMENTAL																															
ESS	ES	.33	.56	.19	+02	+30	.07	.67	.67	.62	.49	---	.49	.67	---	.66	.67	---	.66	---	---	---	---	---	---	+39	---	+39	.26	.25	.26
	SES	.18	.46	.14	.08	.82	.27	.15	.21	.21	.14	---	---	.69	---	---	.49	---	---	---	---	---	---	---	---	.11	---	---	.08	.32	.14
	N	12	3	3	18	2	2	14	2	2	4	---	1	2	---	1	2	---	1	---	---	---	---	---	---	5	---	1	55	9	9
SAPA	ES	.88	1.14	.71	.02	+01	.06	.23	.20	.26	.18	.15	.23	.30	.26	.46	.31	.31	.31	.14	.09	.17	.15	.21	.12	.13	.12	.14	.37	.41	.35
	SES	.14	.69	.25	.11	.16	.06	.13	.38	.38	.08	.27	.16	.18	.20	.23	.16	.05	.05	.07	.07	.05	.14	.10	.05	.12	.12	.08	.06	.51	.09
	N	50	11	11	21	8	8	15	2	2	33	6	6	8	5	5	3	3	3	13	4	4	10	2	2	20	4	4	174	22	22
SCIS	ES	.44	.43	.43	.22	.16	.26	.22	---	.22	.14	.14	.11	.16	.15	.14	.25	.24	.21	.07	.08	.06	.34	.39	.34	.53	.52	.52	.32	.32	.34
	SES	.09	.10	.15	.09	.36	.16	.12	---	---	.09	.12	.11	.08	.10	.08	.08	.18	.13	.08	.05	.08	.08	.12	.17	.26	.26	.26	.04	.13	.03
	N	.65	14	14	24	6	6	7	---	1	10	4	4	25	9	9	19	8	8	5	3	3	10	3	3	4	4	4	159	28	28
CONTROL																															
Teacher Autonomous, Undefined	ES	.73	.89	.59	.30	.29	.30	.38	.37	.41	.26	.27	.26	.38	.18	.59	.21	---	.21	.11	.10	.12	.25	.25	.25	+01	+06	.21	.44	.48	.43
	SES	.12	.57	.22	.11	.31	.21	.13	.30	.29	.08	.13	.11	.54	.62	.62	---	---	---	.06	.05	.07	.08	.12	.11	.16	.30	.26	.05	.34	.11
	N	66	14	14	15	4	4	22	3	3	21	7	7	3	2	2	1	---	1	7	5	5	20	5	5	15	5	5	181	29	29
Text	ES	.49	.45	.59	+07	+11	.02	.43	.43	.43	.18	.17	.18	.20	.19	.27	.30	.29	.32	.12	.07	.14	---	---	---	.37	.35	.45	.25	.24	.31
	SES	.08	.14	.22	.07	.14	.06	.11	.21	.21	.07	.25	.17	.07	.10	.10	.08	.15	.12	.08	.09	.03	---	---	---	.15	.05	.13	.04	.17	.08
	N	52	13	13	34	9	9	14	2	2	38	4	4	31	13	13	22	11	11	11	2	2	---	---	---	9	3	3	189	26	26
Lab or Lab-Text	ES	.29	.39	.15	.21	.19	.19	---	---	---	---	---	---	.18	---	.18	.18	---	.18	---	---	---	---	---	---	+09	+16	+03	.20	.26	.15
	SES	.45	.21	.26	.11	.30	.18	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	.13	.12	.12	.14	.30	.11
	N	9	4	4	14	4	4	---	---	---	---	---	---	1	---	1	1	---	1	---	---	---	---	---	---	5	2	2	30	8	8
TEACHER																															
Experimentor, Same E&C	ES	.37	---	.37	+20	---	+20	.67	.67	.67	.50	.60	.31	.67	---	.66	.67	---	.66	+10	---	+10	.40	---	.40	+39	---	+39	.29	.29	.29
	SES	.24	---	---	.07	---	---	.15	.21	.21	.10	.20	.20	.49	---	---	.47	---	---	---	---	---	.09	---	---	.11	---	---	.07	.21	.16
	N	5	---	1	12	---	1	14	2	2	12	3	3	2	---	1	2	---	1	1	---	1	7	---	1	5	---	1	58	8	8
Volunteers	ES	.30	.34	.18	.09	+12	.18	+13	---	+13	.46	.51	.40	.18	.14	.29	.12	.12	.12	.32	---	.32	.60	---	.60	1.17	---	1.17	.20	.15	.28
	SES	.14	.20	.19	.07	.39	.18	.04	---	---	.11	.09	.09	.12	.27	.23	.58	.15	.05	---	---	---	---	---	---	---	---	---	.05	.39	.12
	N	17	5	5	31	5	5	8	---	1	5	2	2	12	5	5	10	4	4	1	---	1	1	---	1	1	---	1	79	11	11
Mandated, random	ES	.66	.69	.60	25	.28	.19	.43	.43	.43	.10	.10	.12	.20	.19	.24	.37	.37	.31	.12	.11	.13	.13	.18	.09	.15	.14	.21	.38	.39	.37
	SES	.09	.29	.15	.11	.20	.08	.11	.21	.21	.06	.13	.12	.09	.08	.10	.10	.12	.14	.06	.02	.02	.12	.10	.04	.10	.09	.09	.04	.24	.07
	N	105	22	22	20	8	8	14	2	2	42	7	7	21	9	9	12	7	7	16	5	5	12	3	3	23	7	7	263	39	39
TREATMENT DURATION																															
One year or less	ES		.68	.56	.08	.00	.20		.44	.46		.34	.31		.22	.33	.25	.22	.31	.06	.06	.06	.25	.25	.25	+01	+01	.10	.38	.39	.34
	SES		.39	.16		.29	.13		.23	.21		.12	.12		.16	.10	.09	.19	.03	.09	.09	.09	.08	.12	.11	.12	.19	.24	.04	.24	.06
	N		17	17	49	8	8		4	4		7	7		7	7	1$	6	6	3	3	3	20	5	5	17	6	6	279	38	38
More than one year	ES		.50	.46		.19	.10		---	.22		+05	.09		.18	.24	.36	.38	.24	.13	.11	.17	---	---	---	.25	.24	.32	.22	.20	.34
	SES		.21	.20		.08	.05		---	---		.10	.11		.12	.17	.14	.17	.17	.06	.04	.05	---	---	---	.17	.07	.13	.05	.19	.11
	N		12	12		6	6		---	1/		4	4		8	8	9	6	6	15	4	4	---	---	---	12	4	4	121	20	20
SAMPLE SIZE																															
Ten or more classes	ES		1.05	.77		.02	.11		.55	.55	.23	.23	.24		.20	.47	.34	.27	.43	.11	.11	.12	.23	.24	.17	+01	.00	.03	.37	.39	.37
	SES		.42	.21		.36	.12		.14	.14	.06	.13	.09		.24	.16	.12	.40	.15	.06	.02	.06	.08	.13	.08	.11	.15	.11	.04	.26	.07
	N		12	12		6	6		4	4	50	10	10		7	7	13	5	5	16	6	6	19	4	4	19	5	5	261	34	34
Less than ten classes	ES		.35	.33		.10	.16		---	+13	.08	+03	.19		.17	.12	.23	.25	.16	.17	---	.17	.60	---	.60	.20	.23	.53	.25	.25	.30
	SES		.08	.13		.19	.11		---	---	.13	.33	.33		.09	.10	.09	.10	.11	.11	---	---	---	---	---	.00	.19	.22	.26	.04	.14	.09
	N		17	17		9	9		---	1	4	2	2		[illegible]	3	11	[illegible]	[illegible]	2	---	1	1	---	1	19	4	4	129	21	21

TABLE 4 Mean Effect Sizes Calculated by Three Different Techniques for Several Outcome Areas and For Different PUBLICATION FEATURES

		OUTCOMES AREAS																													
		SCIENCE PROCESS			SCIENCE CONTENT			CREATIVITY			LANGUAGE			ALL AFFECT			ATTITUDE			MATH			PERCEPTION			LOGIC			OUTCOMES COMBINED		
		Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies	Comparisons	Jackknife	Studies
PUBLICATION FEATURES																															
SOURCE OF STUDY																															
Unpublished dissertation	ES	.72	.90	.38	.02	-.02	.12	.38	.38	.40	.27	.27	.24	.18	.17	.26	.26	.26	.21	.11	.10	.12	.27	.26	.30	.01	.01	.26	.34	.36	.25
	SES	.12	.55	.20	.06	.20	.11	.09	.23	.22	.08	.07	.10	.10	.09	.16	.11	.14	.14	.07	.06	.09	.08	.10	.13	.13	.21	.33	.04	.29	.07
	N	63	15	15	49	9	9	29	4	4	26	7	7	21	9	9	13	7	7	6	4	4	18	4	4	15	4	4	230	35	35
Published reports	ES	.48	.46	.67	.31	.36	.24	.47	---	.47	.16	.14	.17	.22	.19	.28	.28	.22	.34	.12	.10	.12	.07	---	.06	.18	.17	.25	.32	.31	.48
	SES	.08	.09	.13	.14	.31	.10	.24	---	---	.07	.28	.16	.11	.13	.11	.15	.21	.12	.08	.04	.02	.30	---	.00	.16	.15	.13	.05	.16	.39
	N	64	13	13	14	5	5	7	---	1	33	5	5	11	5	5	8	4	4	12	3	3	2	---	1	14	5	5	159	22	22
YEAR OF STUDY																															
1967 - 1969	ES	1.00	1.53	.68	.07	---	.07	-.13	---	-.13	-.10	---	-.10	.69	---	.69	---	---	---	.09	---	.09	.15	.21	.12	---	---	---	.60	1.07	.20
	SES	.19	.79	.55	.39	---	.00	.04	---	---	.09	---	---	---	---	---	---	---	---	---	---	---	.14	.10	.05	---	---	---	.13	1.18	.23
	N	33	5	5	3	---	1	8	---	1	3	---	1	1	---	1	---	---	---	1	---	1	10	2	2	---	---	---	59	6	6
1970 - 1972	ES	.40	.40	.36	.12	-.18	.22	---	---	---	.20	.24	.18	.50	.50	.50	.15	.15	.15	.15	.12	.20	.22	.12	.31	-.01	.00	.00	.25	.25	.26
	SES	.10	.11	.21	.07	.48	.21	---	---	---	.08	.10	.09	.36	.36	.36	.14	.14	.14	.07	.09	.07	.20	.29	.29	.12	.16	.13	.05	.14	.09
	N	48	8	8	27	3	3	---	---	---	19	4	4	3	3	3	2	2	2	5	3	3	3	2	2	18	4	4	134	18	18
1973 - 1975	ES	.57	.56	.64	.04	-.08	.19	.43	.43	.43	.59	.60	.56	.18	.17	.24	.39	.37	.41	-.10	---	-.10	.40	---	.40	.18	.01	.42	.36	.34	.49
	SES	.13	.14	.14	.10	.29	.17	.11	.21	.21	.05	.07	.11	.05	.07	.08	.10	.14	.10	---	---	---	.09	---	---	.25	.40	.38	.05	.15	.10
	N	29	31	11	22	6	[illegible]	14	2	2	14	3	3	23	8	8	14	7	7	1	---	1	7	---	1	6	5	5	117	22	22
1976 - 1978	ES	.35	.37	.27	.09	.09	.09	.67	.67	.67	.02	-.03	.07	-.03	.11	-.17	-.03	.11	-.17	.12	.07	.14	---	---	---	.38	.26	.50	.24	.19	.28
	SES	.13	.13	.18	.15	.05	.02	.15	.21	.21	.07	.28	.16	.15	.24	.24	.15	.24	.24	.08	.09	.03	---	---	---	.25	.20	.20	.05	.31	.11
	N	17	4	4	11	4	4	14	2	2	23	3	3	5	2	2	5	2	2	11	2	2	---	---	---	5	2	2	87	10	10
1979 - 1981	ES	---	---	---	---	---	---	---	---	---	---	---	---	.47	---	.47	.47	---	.47	---	---	---	---	---	---	---	---	---	.47	---	.47
	SES	---	---	---	---	---	---	---	---	---	---	---	---	.27	---	---	.27	---	---	---	---	---	---	---	---	---	---	---	.27	---	---
	N	---	---	---	---	---	---	---	---	---	---	---	---	3	---	1	3	---	1	---	---	---	---	---	---	---	---	---	3	---	1

Bibliography

Studies Included in the Analysis of Activity-Based Elementary Science Program Effects of Student Outcomes (See Table 1)

Allen, L.R. An examination of the classificatory ability of children who have been exposed to one of the 'new' elementary science programs (Doctoral dissertation, University of California at Berkeley, 1967).

Allen, L.R. An evaluation of certain cognitive aspects of the material objects unit of the Science Curriculum Improvement Study elementary science program. Journal of Research in Science Teaching, 1970, 3, 277-281.

Allen, L.R. An examination of the ability of first graders from the Science Curriculum Improvement Study program to describe an object by its properties. Science Education, 1971, 55, 61-67.

Allen, L.R. An evaluation of children's performance on certain cognitive, affective and motivational aspects of the Interaction unit of the Science Curriculum Improvement Study elementary science program. Journal of Research in Science Teaching, 1972, 9, 167-173.

Allen, L.R. An evaluation of children's performance on certain cognitive affective and motivational aspects of the Systems and Subsystems unit of the Science Curriculum Improvement Study elementary science program. Journal of Research in Science Teaching, 1973, 10, 125-134.

Allen, L.R. An examination of the ability of third grade children from the Science Curriculum Improvement Study to identify experiemental variables and to recognize change. Science Education, 1973, 57, 135-151.

Ayers, J.B. & Mason, G.E. Differential effects of Science-A Process Approach upon change in Metropolitan Readiness Test scores among kindergarten children. The Reading Teacher, 1969, 22, 435-439.

Barksdale, A.T. An evaluation of the Elementary Science Study Program in selected classrooms in East Baton Rouge Parish, Louisian (Doctoral dissertation, Louisiana State, 1973).

Battaglini, D.W. An experimental study of the Science Curriculum Improvement Study involving fourth graders' ability to understand concepts of relative position and motion using the planetarium as a testing device (Doctoral dissertation, Michigan State University, 1971).

Beard, Jean. The development of group achievement tests for two basic processes of AAAS Science - A Process Approach. Journal of Research in Science Teaching, 1971, 8, 179-183.

Billings, G.W. The effect of verbal introduction of science concepts on the acquisition of these concepts by children at the second grade level (Doctoral dissertation, University of Connecticut, 1976).

Blomberg, K.J. A study of the effectiveness of three methods of teaching science in the sixth grade (Doctoral dissertation, University of Minnesota, 1974).

Bowyer, J.B. & Linn, M.C. Effectiveness of the science improvement Study in Teaching Scientific Literacy. Journal of Research in Science Teaching, 1978, 15, 209-219.

Bredderman, T.A. Elementary school science experience and the ability to combine and control variables. Science Education, 1974, 58, 457-469.

Brown, T.W. The influence of the science curriculum improvement study on affective process development and creative thinking (Doctoral dissertation, University of Oklahoma, 1973).

Bullock, J.T. A comparison of the relative effectiveness of three types of elementary school science curricula in the development of problem solving skills (Doctoral dissertation, University of Florida, 1972).

Cleminson, R.W. A comparative study of three fifth grade classrooms on five selected Piaget-type tasks dealing with science related concepts (Doctoral dissertation, University of Iowa, 1970).

Coffia, W.J. The effects of an inquiry-oriented curriculum in science on child's achievement in selected academic areas (Doctoral Dissertation, University of Oklahoma, 1971).

Davis, T., Raymond, A., MacRawls, C., Jordan, J. A comparison of achievement and creativity of elementary school students using projects vs. textbook programs. Journal of Research in Science Teaching, 1976, 13, 205-212.

Eaton, D. An investigation of the effects of an in-service workshop designed to implement the Science Curriculum Improvement Study upon selected teacher-pupil behaviors and perceptions (Doctoral dissertation, West Vriginia University, 1974).

Fick, D.L. The effects of two selected elementary science study units on divergent-productive thinking and nonverbal cognitive abilities (Doctoral dissertation, Oregon State University, 1976).

Hansen, G. An investigation of the influence of two different elementary school programs (Doctoral dissertation, University of Iowa, 1973).

Heath, P.A. The effect of contemporary elementary science programs of selected aspects of science reading achievement (Doctoral dissertation, Oklahoma State, 1970).

Hofman, H.H. A study conducted within selected schools in Saint Paul, Minnesota designed to assess eight-year old children's attitudes toward science (Doctoral dissertation, University of Minnesota, 1973).

Howe, A.C. & Butts, D.P. The effect of instruction on the acquisition of conservation of volume. Journal of Research in Science Teaching, 1970, 7, 371-375.

Huff, Phyllis. The effects of the use of activities of SAPA on the oral communication skills of disadvantaged kindergarten children. Journal of Research in Science Teaching, 1973, 10, 165-173.

Hunts[illegible]ger, John. Developing divergent-productive thinking [illegible] elementary school children using attribute games a[illegible] problems. Journal of Research in Science Teaching, 1976, 13, 185-191.

Jacknicke, K. A comparison of teacher and student outcomes of science - A process approach and an alternative program in selected grade two classrooms (Doctoral dissertation, University of Colorado, 1975).

Johnson, J.K. Effects of the process approach upon IQ measures of disadvantaged children. Science Education, 1970, 54, 45-47.

Johnson, R.T. & Ryan, F.L. & Schroeder, Helen. Inquiry and the development of positive attitudes. Science Education, 1974, 58, 51-56.

Judge, Joan. Observational skills of children in Montessori and science - A process approach classes. Journal of Research in Science Teaching, 1975, 12, 407-413.

Kellogg, D.H. An investigation of the effect of science curriculum improvement study's first year unit, material objects, on gains in reading readiness (Doctoral dissertation, University of Oklahoma, 1971).

Kolebas, P. The effects on the intelligence, reading, mathematics, and interest in science levels of third grade students who have participated in science - A process approach since first entering school (Doctoral dissertation, University of Virginia, 1971).

Krockover, G.H. & Malcolm, M.D. The effects of the science curriculum study on a child's self-concept. Journal of Research in Science Teaching, 1977, 14, 295-300.

Labinowich, E.P. A study in summative evaluation of elementary school science curricula (Doctoral dissertation, Florida State University, 1970).

Linn, M.C. An experimental science curriculum for the visually impaired. Exceptional Children, 1972, 38, 37-43.

Linn, M.C. & Peterson, R.W. The effect of direct experience with objects on middle class, culturally diverse, and visually impaired young children. Journal of Research in Science Teaching, 1973, 10, 83-90.

Linn, M.C. & Thier, H.D. The effect of experimental science on development of logical thinking in children. Journal of Research in Science Teaching, 1975, 12, 49-62.

Long, N.L. Science Curriculum Improvement Study (SCIS): Its effect on concept development and manipulative skills in visually handicapped children (Doctoral dissertation, University of California at Berkeley, 1973).

Lowery, L.F., Bowyer, J., & Padilla, M.J. The science curriculum improvement study and student attitudes. Journal of Research in Science Teaching, 1980, 17, 327-355.

Mansfield, J.L.J. The effect of the Elementary Science Study on selected science skills of educable mentally retarded students (Doctoral dissertation, Ball State University, 1976).

Maxwell, D.E. The effects of selected science activities on the attainment of reading readiness skills with kindergarten children (Doctoral dissertation, Michigan State University, 1974).

McGlathery, G.E. An assessment of science achievement of five and six year old students of contrasting socio-economic backgrounds (Doctoral dissertation, University of Texas, 1968).

Novinsky, J.E. A summative evaluation of two programs in elementary school science relative to measurable differences in achievement, creativity and attitudes of fifth grade pupils in the United States Dependents School, European Area (Doctoral dissertation, University of Southern California, 1974).

Partin, M. An investigation of the effectiveness of the AAAS process method upon the achievement and interest in science for selected fourth grade students (Doctoral dissertation, University of Southern Mississippi, 1967).

Ranson, W.E. The effect of Science - A Process Approach on creative thinking and performance in selected processes of science in the second grade (Doctoral dissertation, Syracuse University, 1968).

Raven, R.J. & Calvey, Sister Helen. Achievement on a test of Piaget's operative comprehension as a function of a process oriented elementary school science program. Science Education, 1977, 61, 159-166.

Riley, J.W. The development and use of a group process test for selected processes of the Science Curriculum Improvement Study (Doctoral dissertation, Michigan State University, 1972).

Schmedemann, G.D. The influence of curriculum differences and selected teaching strategies on the cognitive preference of elementary school science students (Doctoral dissertation, University of Kansas, 1969).

Smith, B. A modern elementary science curricula and student achievement (Doctoral dissertation, Western Michigan University, 1972).

Somers, R.L & Lagdamen, J.M. The effect of a modern elementary science curriculum on the ability of Filipino children to observe, compare and classify geometric figures. Journal of Research in Science Teaching, 1975, 12, 297-303.

Stafford, D.G. The influence of the first grade program of the Science Curriculum Improvement Study on the rate of attainment of conservation (Doctoral dissertation, University of Oklahoma, 1969).

Studies Included in the Analysis of the Effects of Activity-Based Elementary Science Programs on Classroom Practices (See Table 6).

Bruce, L.R. A determination of the relationships among SCIS teachers' personality traits, attitude toward teacher - pupil relationship, understanding of science process skills and question types (Doctoral dissertation, Michigan State University, 1969).

Eaton, D. An investigation of the effects of an in-service workshop designed to implement the science curriculum improvement study upon selected teacher-pupil behaviors and perceptions (Doctoral dissertation, West Virginia University, 1974).

Fischler, A.S. Science, process, the learner: A synthesis. Science Education, 1965, 49, 402-409.

Gates, T.G. An experimental evaluation of the effects of a 106 science in-service model on teacher attitudes and levels of questioning in the elementary science study program (Doctoral dissertation, University of Virginia, 1976).

Hall, G.E. Teacher-pupil behaviors exhibited by two groups of second grade teachers using Science - A Process Approach. Science Education, 1970, 54, 325-334.

Harty, H. The implementation consultant and classroom teacher - pupil verbal interaction. Science Education, 1976, 60, 39-46.

Horine, N.W. A comparison of inquiry activities in elementary science classes by means of tape recordings (Doctoral dissertation, University of Missouri, 1970).

Moon, T.C. A study of verbal behavior patterns in primary grade classrooms during science activities. Journal of Research in Science Teaching, 1971, 8, 171-177.

Newport, J.F. & McNeill, K. A comparison of teacher-pupil verbal behavior evoked by Science - A Process Approach and by textbooks. Journal of Research in Science Teaching, 1970, 7, 191-195.

Porterfield, D.R. Influence of preparation in Science Curriculum Improvement Study on questioning behavior of selected second and fourth grade reading teachers (Doctoral dissertation, The University of Oklahoma, 1969).

Westmeyer, P. A comparison of various techniques for the dissemination of a new science curriculum in Florida. Tallahassee, FL: Florida State University, 1967.

Wilson, J.H. & Genner, J.W. The 'new' science and the rationale powers: A research study. Journal of Research in Science Teaching, 1969, 6, 303-308.

Smeraglio, A. & Honigman, F.K. Examining behavioral differences between 'new' and 'traditional' methods of elementary science instruction. New York, NY: Institute for Educational Development, 1973.

Smith, H.A. Curriculum development and instructional materials. Review of Educational Research, 1969, 39, 397-413.

Voelker, A.M. Elementary school children's attainment of the concepts of physical and chemical change - A replication. Journal of Research in Science Teaching, 1975, 12, 5-14.

Vognchusiri, P. The effects of alternative instructional methods on the achievement of science students in the elementary schools of Northeast Thailand (Doctoral dissertation, Cornell University, 1974).

Victor, E. & Lerner, M.S. Readings in science education for the elementary school. New York: MacMillan, 1971.

Walcott, C. On evaluation. ESS Newletter. February 1965, pp. 1-2.

Welch, W.W. Twenty years of science curriculum development: A look back. In D.C. Berliner (Ed.), Review of research in education (Vol. 7). Washington, D.C., American Educational Research Association, 1979.

References

Arnold, D.S. & Atwood, R.K., & Rogers, V.M. An investigation of the relationships among question level, response level and lapse time. Schcol Science and Mathematics, 1973, 73, 591-594.

Atkin, J.M. Comments on two approaches. Science. March 1966, 151, 1033-1055.

Ausubel, D.P. Some psychological considerations in the objectives and design of an elementary school science program. Science Education, April 1963, 47, 278-284.

Campbell, D.T. & Stanley, J.C. Experimental and quasi-experimental designs for research on teaching. In N.L. Gage (Ed.), Handbook of research on teaching. Chicago: Rand McNally, 1963.

Cohen, J. Statistical power analysis for the behavioral sciences (Rev. ed.). New York: Academic Press, 1971.

Davis, M. The effectiveness of a guided - inquiry discovery approach in an elementary school science curriculum. (Doctoral dissertation, the University of Southern California, 1978).

Fischler, A.S. & Anastasiow, N.J. In-service education in science (a plot) the school within a school. _Journal of Research in Science Teaching_, 1965, _3_, 28-285.

Gagne, R.M. Elementary science: A new scheme of instruction. _Science_. 1966, 151, 49-53.

Gallagher, J. A summary of research in science education for the years 1968-1969: Elementary school level, _Journal of Research in Science Teaching_, 1972, _9_, 19-46.

Glass, G.V., McGaw B., & Smith, M.L. Meta-Analysis in social research. Beverly Hills: Sage Publications, 1981.

Glass, G.V. Integrating findings: The meta-analysis of research. In L.S. Shulman (Ed.), _Review of Research in Education_ (Vol. 5). Itasca, IL: F.E. Peacock, 1978.

Karplus, R. Physics for beginners. _Physics Today_, 1972, _25_ (6), 36-47.

Karplus, R. & Thier, H. Toward scientific literacy. Boston: D.C. Heath, 1966.

Karplus, R. The Science Curriculum Improvement Study. _Journal of Research in Science Teaching_, 1964, _2_, 293-303.

Kulik, J.A., Kulik, C., & Cohen, P.A. Effectiveness of computer-based college teaching: a meta-analysis of findings. _Review of Educational Research_, 1980, 50, 525-544.

Labahn, W. So you want to provide a modern science program. _School Science and Mathematics_, November 1966, _66_, 695-699.

Marlins, J.G. A study of the effects of using the Counter-intuitive event in science teaching on subject-Matter Achievement and subject matter retention of Upper-Elementary school students (Doctoral dissertation, The American University, 1973).

Peterson, P.L. Direct and open instructional approaches: Effective for what or whom? Working Paper No. 243, Wisconsin Research and Development Center for Individualized Schooling, October 1978.